DAVID ALDEN LEAVENS
Communicating about Distal Objects: an Experimental Investigation of Factors Influencing Gestural Communication by Chimpanzees (*Pan troglodytes*)
(Under the Direction of ROGER K. THOMAS, JR.)

A defining characteristic of intentional communication is that it is used socially; that is, an audience is required for the display of communicative behavior. A second defining feature of intentional communication is that it locates objects in time or space for an observer. Previous studies of these features of manual gesture in apes have employed very small samples (one to four subjects). The present studies explored (a) the independent effects of the arrival of an experimenter and food on gestural production in chimpanzees (N = 35, Experiment 1), (b) the influence of food dispersion on the number of fingers extended while pointing (N = 83, Experiment 2), and (c) the effectiveness of chimpanzees in communicating the location of hidden food (N = 101, Experiment 3). The methods employed in these experiments differ from those used in previous studies in the following ways: (a) large samples were used, (b) only first-trial results were analyzed (i.e., every subject received each experimental condition only once), (c) "naturalistic" procedures avoided potential confounds with the effects of novel apparatus or unusual behavior on the part of the experimenters, and (d) the experiments sampled from a population of chimpanzees who had not been language-trained or otherwise raised in intimate association with humans. The chimpanzees gestured almost exclusively during the approach or presence of a human observer (Experiment 1).

Experiment 2 was inconclusive because too few chimpanzees pointed. A human observer was able to correctly guess the location of a hidden banana on 71% of 97 trials, demonstrating that chimpanzees can effectively communicate the location of hidden food without explicit training to do so.

INDEX WORDS: Chimpanzees, *Pan troglodytes*, Intentional communication, Gestures, Audience effect, Pointing, Apes.

COMMUNICATING ABOUT DISTAL OBJECTS: AN EXPERIMENTAL INVESTIGATION OF FACTORS INFLUENCING GESTURAL COMMUNICATION BY CHIMPANZEES (*Pan troglodytes*)

by

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DEDICATION

This dissertation is dedicated to the late James H. Kashiwagi (1930-1999), my step-father, with love and appreciation for his continued belief in my goals, despite spectacular failures too numerous to list.

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The difficulty with a lengthy series of acknowledgments is that it can be construed to imply the author's exaggerated estimation of the pages which follow. Balanced against this is the obligation to express the present author's unusually large degree of indebtedness to many individuals, without whose help and support at critical times, he would never have been in a position to submit a dissertation. It is in consideration of this latter obligation that I wish to thank the following people. Rodger Harris Smith, Ken Boone, Dennis Langworthy and numerous friends of Bill W. were instrumental in helping me overcome alcoholism. I think that if everybody had a grandparent like my late grandfather, Frank B. Leavens, the world would be a kinder, gentler place; I thank him for his boundless indulgence of a small boy's curiosity about how the world works. My parents, Carol and the late Jim Kashiwagi, were unusually permissive parents; perhaps the best thing they ever did for me was respect my very early and lifelong skepticism over the accuracy of the bible as a historical record. Cynthia L. Morgan introduced me to polite society. Lori Rose Weingartner was the catalyst for my decision to pursue a career in academia.

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infectious enthusiasm often provided a much needed boost in my morale, as one or another experiment encountered snags. His laboratory has been both a source of learning and a friendly place to be. It's not possible to adequately express my appreciation for what was the first productive research relationship of my professional life and what continues to be a warm and intellectually stimulating state of comradery.

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CHAPTER 1

INTRODUCTION

In recent years, pointing behavior has drawn increasing experimental and theoretical attention from human developmental researchers, who view pointing primarily in relation to its significance for the onset of speech (e.g., Baldwin, 1995; Bates, Camaioni, & Volterra, 1975; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1977; Blake & Dolgoy, 1993; Butterworth & Grover, 1988; Butterworth, 1991, 2000; Horne & Lowe, 1996; Werner & Kaplan, 1963). There is a considerable body of evidence that identifies pointing as a covariate of verbal labeling (i.e., naming) in the social environments in which human infants learn to associate verbalizations with specific objects in the environment. Butterworth and Itakura (2000) reported that infants from six to seventeen months of age followed pointing-to-objects located further in the periphery from their midlines than they followed head-turning alone, demonstrating that pointing serves as a more effective mechanism for the re-direction of visual attention to peripheral objects than head-turning alone (similar findings were reported by Deák, Flom, & Pick, 2000). Studies by Baldwin and her colleagues (Baldwin, 1993, 1995; Baldwin & Moses, 1994) have manipulated the congruence between experimenters' utterances and both the experimenters' and infants' visual attention, demonstrating that by 18 months of age, human infants

associate verbal labels not with the object at which they themselves are looking when the verbal label is uttered, but with a different object, at which the experimenter is looking when the label is uttered. Butterworth (2000) suggested that "pointing . . . authorises visual objects to take on auditory qualities and this is an early means for the infant to learn that objects have names" (p. 189).

The production of pointing by human infants has also been interpreted primarily as a precursor to linguistic reference. Some infants begin to point, to direct their outstretched arm and index finger toward distant objects, by 9 months of age (Figure 1). By 11 to 12.5 months of age, most infants point (Figure 1) to objects in their environments and the majority (76% to 88%, depending on the study) of infant points are accompanied by vocalizations (Dobrich & Scarborough, 1984; Franco & Butterworth, 1996; Leung & Rheingold, 1981; Masur, 1983; Zinober & Martlew, 1985). Pointing by human infants is exhibited by the majority of subjects in diverse experimental or naturalistic settings by the end of the first year of life, and pointing is accompanied by high rates of vocal behavior. Few studies differentiate these infant vocalizations while pointing into linguistic versus nonlinguistic categories. Masur (1983) found that 25% of all points exhibited by four infants studied from eight to 18 months of age were accompanied by recognizable speech. Similarly, Zinober and Martlew (1985) found that 40% of all points exhibited by two infants from 10 to 21 months of age were accompanied by recognizable speech. Thus, although pointing by human infants is

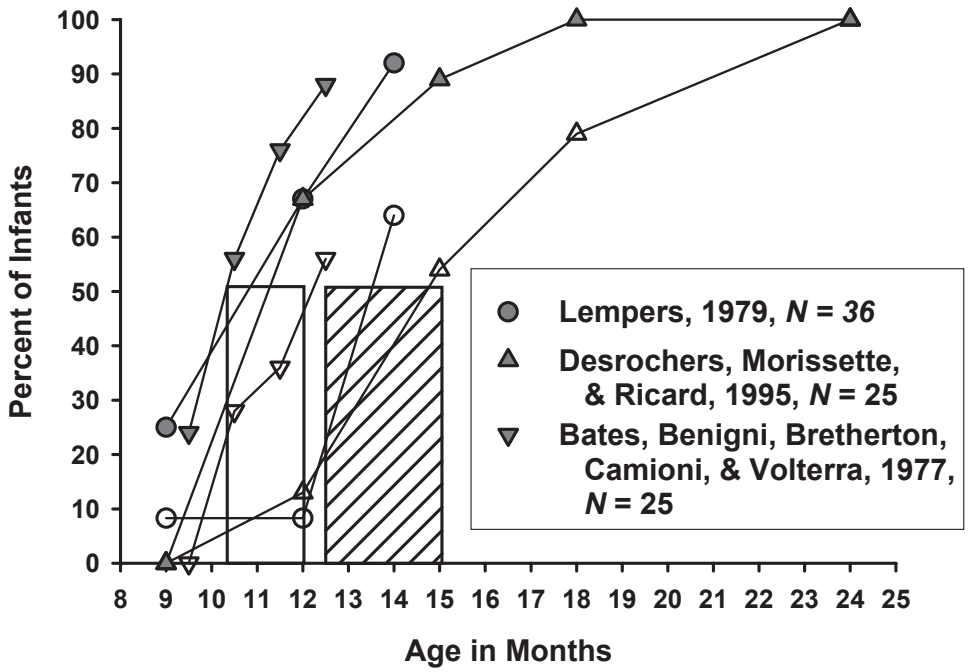

Figure 1. The development of pointing with concomitant gaze alternation between objects and social agents in human infants. Filled symbols denote pointing without gaze alternation, whereas hollow symbols denote pointing with gaze alternation. The open box shows the age range over which at least 50% of the infants in each study exhibited pointing. The box with diagonal lines shows the age range over which at least 50% of the infants in each study exhibited pointing with concomitant gaze alternation between the object pointed to and social agents. (Figure is elaborated from Leavens & Hopkins, 1999, Figure 2b; used here with permission of the American Psychological Association.)

frequently accompanied by speech, and serves in these instances as a paralinguistic gesture, pointing is by no means exclusively associated with speech.

Pointing is generally characterized as a milestone in a series of developmental events reflecting increasing sophistication in the capture and manipulation of the

behaviors of other social agents (e.g., Adamson, 1996; Adamson & MacArthur, 1995; Bates et al., 1975; Butterworth, 1991, 2000, in press; Werner & Kaplan, 1963). Prior to this watershed, infants' abilities to enter into states of joint attention to distal objects with other social agents is extensively supported by these social agents, usually the infants' primary caregivers (Adamson & Bakeman, 1991). For example, Bakeman and Adamson (1984) observed infants at three-month intervals from 6 to 18 months of age in free-play contexts with their mothers and peers in their homes. Of particular interest was how episodes of both the mother and the infant looking at the same object were coordinated ("scaffolded") by the mothers' behavior. Bakeman and Adamson (1984) found that, over the age range studied, infants' visual attention to objects was both a significant antecedent and a consequent of mothers' actions on these objects (shaking a rattle, "ringing" a toy telephone, etc.); in other words, mothers' object-directed behaviors served to bring the infants and the mothers into states of joint attention with these objects long before infants evinced any capacity for directing the visual attention of others.

After approximately 9 months of age, however, human infants begin to take an active role in capturing and re-directing the visual attention of their caregivers and other social agents (e.g., Bates et al., 1975; Butterworth, 2000, in press; Desrochers et al., 1995; Lempers, 1979). This transition has been variously termed a transition to "intentional communication" (Bates et al., 1975), to "robust triadic joint visual attention" (e.g., Butterworth, in

press), or to "secondary intersubjectivity" (Trevarthan & Hubley, 1978). This biobehavioral shift at approximately 9 months of age is characterized as a new integration of the abilities (a) to act on objects with (b) the ability to communicate through gestures with social agents in goal-directed sequences of activity (Bard, 1992; cf. Sugarman, 1984).

There is a further development that occurs at approximately 15 months of age: Infants now begin to exhibit gaze-orienting behavior successively between objects and social agents as they gesture (Figure 1; Bates et al., 1977; Desrocher, Morissette, & Ricard, 1995; Lempers, 1979). Infants as young as 6 months do successively alternate their gaze between objects and their social partners (Adamson, 1996; Leavens & Todd, unpublished data), but generally human infants do not integrate this gaze alternating behavior with their gestural behavior until much later, typically 13 months of age or later (Figure 1). Still later, at approximately 18 months of age, infants begin to look to their social partners significantly more often prior to gesturing than during the gesture or after the gesture (Franco, personal communication, November 23, 2000; Franco & Butterworth, 1996). This transition to a pattern of behavior that integrates gestures with visual orienting to a social agent is heralded by many developmental researchers as the canonical marker of intentional communication (e.g., Bates et al., 1975, 1977; Petitto, 1988; Tomasello, 1995).

Intentional communication has been variously defined. A distinction is offered here between behavioral definitions

and mentalistic definitions. An example of a behavioral definition of intentional communication is that by Bard (1992): "the ability to coordinate sequences of behavior involving objects with sequences of behavior involving social agents" (Bard, 1992, p. 1187; cf. Sugarman, 1984). According to this definition, then, intentional communication is a manipulative capacity that operates in the social domain. Numerous positive correlations have been reported between measures of means-ends abilities (i.e., the ability to use objects to act on other objects) and various components of intentional communication, including age at pointing onset and age at which pointing is accompanied by gaze alternation (Bates et al., 1977, Bates, Thal, Whitesell, Fenson, & Oakes, 1989; Bates, Thal, & Marchman, 1991; Harding & Golinkoff, 1979; Sugarman, 1984). Thus, according to this definition, intentional communication is a kind of "social tool use" (e.g., Bard, 1990).

In contrast, mentalistic definitions of intentional communication define it in terms of the intentions of the signaler (e.g., Baron-Cohen, 1999; Sperber & Wilson, 1986). For example, Baron-Cohen (1999) defined intentional communication as "communicative acts that are produced in order to change the knowledge state of the listener" (p. 262). Mere use of gesture to influence an observer to acquire otherwise unreachable food would not be intentional communication in a mentalistic perspective, because this does not necessarily constitute evidence of (a) the recognition that others have mental states that may differ from one's own or (b) an attempt to alter the mental state

of the observer, both of which are implied by mentalistic definitions of intentional communication.

The difference between behavioral and mentalistic definitions of intentional is highlighted by the distinction between protoimperative pointing (pointing to request objects) and protodeclarative pointing (pointing to share attention to, or comment upon, distant objects or events). A vigorous research program launched in the 1970's by Bates and her colleagues has sought to test Piaget's (e.g., Piaget & Inhelder, 1969) claim that language acquistion in childhood is subsidiary to, or derived from, changes in cognitive competence (e.g., Bates et al., 1975, 1977, 1989, 1991). Bates and her associates have explored the early prelinguistic communicative repertoires of infants in terms of the pragmatic functions of language, which they derived from Austin's (1962) Speech Act Theory. Like many pragmatic accounts (cf. Skinner, 1957), this perspective on language emphasizes the functions of linguistic communication: a speech act can serve to enact a state of matrimony, bind parties into contracts, request objects, request information, to comment upon an event, person, or object, etc. Bates and associates (e.g., Bates et al., 1975) then extended these linguistic functional categories to the domain of prelinguistic communication. Thus, in their account, an act of speech that is requestive in function would be referred to as an "imperative"; whereas a behavioral pattern exhibited by a prelinguistic infant to (apparently) request something, is termed "protoimperative." A speech act that serves to comment on an event, person, or

object, is termed a "declarative," and precursors to mature declaratives are termed "protodeclaratives."

This distinction between protoimperatives and protodeclaratives has been adopted by Baron-Cohen in a number of experimental analyses of the gestural communication of autistic children (summarized in Baron-Cohen, 1995). In short, Baron-Cohen and others have found that although autistic children do point to objects in the context of requesting those objects (protoimperative pointing), they do not generally point to objects to comment upon them (protodeclarative pointing). Baron-Cohen interprets this finding to indicate that autistic children lack a cognitive mechanism for sharing attention; that they do not have the capacity or motivation to engage in joint apprehension of objects as an end in itself.

As used here, "intentional communication" does not refer to a hypothetical motivational state in an organism, which is causal in subsequent behavior (i.e., it is not synonymous with "volitional"), nor is it limited to acts of communication intended to alter the knowledge state of an observer; rather, intentional is used here to describe communicative behaviors that refer to specific objects, locations, events or entities. The term "refer" may require some qualification. Its use here is not intended to describe the motivational basis of communication; rather, an organism(A)is described as standing in a referential relation to a second organism (B) and a third party organism, object, event, or location (C) when both B and C can be demonstrated to have exerted stimulus control over

the postures, gestural orientations, or visual orienting behavior of A. "Intentional communication," therefore, is behavior that integrates event- or object-oriented behaviors with behaviors that capture and re-direct the attention of another social agent and is used flexibly in a manner that is sensitive to the behavioral cues of the attentional status of an observer. This functional approach follows that advocated by Bruner (1975), who noted the "morass into which it leads when one tries to establish whether something was *really*, or *consciously* intended" (p. 262, emphasis his). The advantage in positing a function (as opposed to a mental state) in a communicative episode is that behavior can be defined with reference to objectively measurable aspects of the context: e.g., the temporal-spatial relations between the orientation of a gesture and objects in an environment, the spatial relations between gaze-orienting behavior and objects and social agents, the influence of observer presence or other observer characteristics on gestural production, etc. "Unintentional communication," then, is behavior by an actor, A, that is not influenced by the presence or visual attention of another social agent, B (e.g. simple reaching), or behavior that is influenced by the presence or other attributes of B, but is not simultaneously under the stimulus control of a third element, C (e.g., fixed, or modal action patterns). It is important to emphasize that the behavioral definition of intentional communication used here is much more general than the more restrictive mentalistic definition--encompassing, as it does, both behaviors exhibited in the

context of requesting things and in the context of sharing attention to, or commenting upon, distant objects or events.

Current theoretical interpretations of the transition to intentional communication are diverse. Piaget (as summarized in Bard, 1987; Butterworth & Harris, 1994; Owens, 1996) proposed a constructionist account of sensorimotor intelligence, which attributed increased behavioral competencies to increasingly hierarchical relations between hypothetical cognitive structures developed through interaction between an organism and its environment. This theoretical perspective is grounded in an explicit analogy between (a) the relationship of mental systems to environmental change and (b) the dynamic interplay between organisms' physical systems and changes in the environment. In the Piagetian perspective, development is characterized as a series of "stages" of cognitive complexity, which occur in invariant order. Development over the course of the infancy period is termed the "Sensorimotor Stage" of development, which is, in turn, subdivided into six substages. Substage IV, termed "coordinated secondary circular reactions," and lasting from approximately nine to 12 months of age, is construed as a level of cognitive organization in which acquired behavioral patterns (termed "secondary circular reactions") are combined into new behavioral complexes. An example of coordinated secondary circular reactions is a sequence of activities in which an infant might reach toward and grasp a cloth that is covering an object (a secondary circular reaction), remove the cloth and release it from its grasp (a second secondary circular

reaction), and reach forward to grasp the revealed object (a third secondary circular reaction) (example from Butterworth & Harris, 1994). The theoretical significance of this stage of development for the advent of intentional communication is that, in the Piagetian framework, this marks the first time in development that goals are specified in advance of behavioral activity. It is also at this age that infants begin to use objects in social interactions with their caregivers (e.g., Adamson, 1996; Bruner, 1983), for example, infants at this age might bang a toy on the substrate and visually orient toward social partners.

Substage V, in the Piagetian framework, is termed "tertiary circular reactions," and lasts from approximately 12 months to 18 months. This stage of development is characterized by the trial-and-error discovery of new means to established ends. Among the behaviors that characterize this stage of development is the use of objects to manipulate other objects (termed "instrumentalization"). An example of instrumentalization is the use of a stick to obtain an otherwise unreachable object. The use of a person to obtain an otherwise unreachable object is considered to be an example of a tertiary circular reaction involving the instrumental use of person to obtain an object (i.e., "social tool use," cf. Bard, 1990).

The relevance of the Piagetian account of human development to the present report is its empirical validity: irrespective of the ontogenetic status of the cognitive changes that are hypothesized to underlie the various behavioral transitions in the first two years of life, these

changes in behavior are exceedingly well-established; the basic observations have been replicated in diverse cultures, in both laboratory and naturalistic contexts. As noted by Scarr-Salapatek (1976), "all nondefective [human] infants reared in natural human environments achieve all of the sensorimotor skills that Piaget has described" (p. 185). The behavioral transition to intentional communication, beginning at about nine months of age, has been isolated as a developmental milestone from numerous theoretical positions, including maturational theories (e.g., Trevarthan & Hubley, 1978), other social constructionist accounts (e.g., Bates et al., 1977, 1979; Bruner, 1983), and behavior analytic approaches to language development (e.g., Horne & Lowe, 1996). Common to all of these theoretical accounts is the empirical transition in human infancy from primarily object-centered activity to an integration of object-centered activities with concurrent social activities (for example, infants at approximately nine months of age begin to take the initiative in games of "give-and-take," Bruner, 1983). Thus, the temporal course of the advent of intentional communication in human infants is a widely recognized, though variously defined, phenomenon (Table 1).

Given the numerous reports relating pointing behavior in humans to language acquisition (e.g., Baldwin, 1995; Bates et al., 1977, 1989; 1991), it is of considerable interest whether, and under what circumstances, our nearest living relatives, the great apes, point to distant objects. The comparative data are reviewed in the next chapter.

Table 1. The development of intentional communication in humans.

Approximate Age Range (in months)	Developmental Milestones
8-12	Use of objects to in face-to-face interaction (joint object engagement).
9-13	Gesturing at objects some distance from both signaler and observer (triadic communication).
12-15	Gesturing with gaze alternation between distant object and observer.

CHAPTER 2

REVIEW OF THE LITERATURE ON POINTING BY APES

In recent decades, numerous authorities have asserted that pointing is a uniquely human behavior (e.g., Butterworth & Grover, 1988; Pettito, 1988; Povinelli & Davis, 1994; Werner & Kaplan, 1963). For example, Petitto claimed that "apes . . . do not point to a referent while moving eye gaze to and fro between the referent and the caretaker to establish joint visual regard" (1988, pp. 216-217). More recently, Povinelli and Davis asserted that

> chimpanzees reared and tested extensively in human laboratories often display reaches that appear to be somewhat like pointing . . . ., however, in such subjects pointing with the index finger does not develop, even in those subjects trained to respond to human indexical pointing (Povinelli & Davis, 1994, p. 134).

Yet, reports of pointing by apes in the scientific literature date to as early as 1916 (Furness, 1916, see Table 2). Because issues of definition often confuse this dialogue, a distinction will be made here between structural and functional definitions of pointing. One can, in both theory and common practice, direct the attention of another social being in a variety of ways. For example, de Waal (2001) describes a common "cocktail party" phenomenon in which a signaler subtly captures the visual attention of a

Table 2. Reports of pointing by apes

Species and source	*N*
Pongo pygmaeus (orangutan)	
Furness, 1916	1
Miles, 1990	1
Gómez & Teixidor, 1992	1
Call & Tomasello, 1994	1*
Gorilla gorilla (gorilla)	
Patterson, 1978	1
Pan paniscus (bonobo)	
Savage-Rumbaugh, Wilkerson, & Bakeman, 1977[a]	3
Savage-Rumbaugh, 1984, 1986	1
Veà & Sabater-Pi, 1998[a]	1
Pan troglodytes (chimpanzee)	
Furness, 1916	1
Kellogg & Kellogg, 1933	1
Hayes & Hayes, 1954	1
Gardner & Gardner, 1971	1
Terrace, 1979	1
Woodruff & Premack, 1979	4
Fouts, Hirsch, & Fouts, 1982	1
de Waal, 1982[a]	2
Bard & Vauclair, 1984[a]	1
Tomasello, George, Kruger, Farrar & Evans, 1985[a]	1
Savage-Rumbaugh, 1986[a]	2
Boysen & Berntson, 1989	1
Povinelli, Nelson, & Boysen, 1990	3*
Leavens, Hopkins, & Bard, 1996	3
Inoue-Nakamura & Matsuzawa, 1997[a]	1+
Krause & Fouts, 1997	2
Whiten, 2000 (cf. C. Menzel, 1999)	1
Leavens & Hopkins, 1998	50*
Total	87+

[a]Pointing as reported in these studies involved ape-ape interactions, pointing as reported in all the other studies cited involved ape-human interaction. Asterisks denote studies that included apes reported to point that were also included in and reported to point in earlier studies cited here; such apes were included only once in the *N* column and, therefore, the Total. Pluses indicate the minimum number of apes reported to point, where the number of pointing apes was not reported.

partner and redirects it toward a party newcomer, with an eyebrow flash and subsequent glance with raised chin toward the newcomer. E. Menzel (1973), discussing the behavioral basis for communication about distant objects in a group of young chimpanzees, described "postural and locomotor pointing" (p. 218). Thus, at the most general level of description, any behavior that "refers to" a distant object, event, location, or social agent can be referred to as pointing; this is a functional definition of pointing. In the human developmental literature, however, the term pointing is restricted to a specific posture of the hand, in which the arm and index finger are extended and the remaining fingers flexed; this, then, is a structural definition of pointing (e.g., Butterworth, 2000).

Further complicating the issue is that humans and apes often indicate distant objects with several or all fingers of the hand extended; these whole-handed finger extensions are typically termed "reaches," despite the apparently communicative function they serve for both humans and apes (e.g., Blake, O'Rourke, & Borzellino, 1992; Franco & Butterworth, 1996; Leung & Rheingold, 1981; see Bruner, 1983, for a distinction between "reach to communicate" and "reach to grasp" and see Leavens & Hopkins, 1999, for terminological and functional discussion of this issue). Leavens and Hopkins (1998, 1999) have argued that the term "reach" is ambiguous; they prefer the term "whole hand point" to describe apparently communicative finger extensions involving multiple digits, distinguishing these from actual attempts at prehension, which they term

"reaches." The present report will use the term pointing in a functional fashion, referring to pointing with the index finger as either "indexical pointing" (e.g., Krause & Fouts, 1997; Leavens, Hopkins, & Bard, 1996; Povinelli & Davis, 1994) or "canonical pointing" (Butterworth, 2000) and to pointing with multiple fingers extended as "whole-hand pointing" (Krause & Fouts, 1997; Leavens et al., 1996; Leavens & Hopkins, 1998, 1999; de Waal, 1982).

Experimental Studies of Pointing by Apes

The first experimental study of pointing by apes was that by Woodruff and Premack (1979), employing a sample of four juvenile chimpanzees (one male, all estimated to have been between 22 and 28 months of age). In this study, one experimenter baited one of two containers in view of one of four chimpanzee subjects. One of two other experimenters then entered the room and attempted to guess which of the two containers had been baited, using cues from the orienting and communicative behaviors of the chimpanzees. On half of the trials, the second experimenter was a "friendly" experimenter who delivered the food to the chimpanzee, if he selected the baited container. On the other half of the trials, the second experimenter was a "competitive" experimenter who removed the banana and then departed the room. The friendly and competitive experimenters dressed in distinctive ways; for example, the competitive experimenter wore a bandana over his face, like a bandit. Two of the four chimpanzees (Jessie and Luvie) inhibited communicative responses and orienting behavior to the baited bucket (including pointing) in the presence of

the competitive experimenter, but not the friendly experimenter. The two other subjects (Sadie and Bert) began to point to the unbaited container in the presence of the competitive experimenter, but continued to point to the baited container in the presence of the friendly experimenter. Pointing was exhibited by all four subjects and was defined as arm or leg protrusions in the direction of one of the containers. The authors emphasized that pointing had not been observed in any other context in this sample. Thus, all four chimpanzees exhibited control over their pointing behavior, adjusting their behavior in accordance with characteristics of their audience (friendly vs. competitive).

The second experimental study of pointing by apes was that by Call and Tomasello (1994), in a study of the production and comprehension of pointing by two orangutans, one sign-language-trained (Miles, 1990) and the other not language-trained. In a test of pointing production, three boxes were placed in wire mesh cages arranged in a row in front of the subjects' cages; one of these boxes was baited in view of the subjects by the first experimenter (E1). Two kinds of trials were administered during pretraining: in tool trials, the second experimenter (E2) waited for the subject to point to one of the boxes and then used a rake to pull the box to the side of the cage, reached in, and delivered the food to the subject (if the subject indicated an empty box, then E2 showed the subject the empty box and departed). In no-tool trials, the boxes were placed in the cages next to the mesh, so that E2 could reach directly

through the mesh to retrieve any food that had been left there. Again, only if the subject indicated, by pointing, to the baited box did the subject get the food; otherwise, as in the tool trials, E2 showed the subject the empty box and departed. After this pretraining period, a hidden tool condition was introduced. In this test condition, the tool used to move the box to the side of its cage was itself hidden by E1 behind one of three screens mounted on the wall opposite the subject's cage. When E2 arrived, he waited for the subject to point to one of the three screens, then, if the rake was found, waited for the subject to point to one of the boxes. Chantek, the language-trained orangutan, performed at high levels during this test, pointing correctly to both the hidden tool location and the hidden food location from the twelth to the twentieth of 21 trials. Puti, in contrast, performed very poorly, failing to point to the tool location on all 21 trials and pointing to the hidden food on only three of the 21 trials. After the tenth trial, Puti ceased responding. Puti was given remedial training, her performance improved, and the authors concluded that the orangutans "seemed to understand something of the communicative value of their pointing gesture in directing a human to entities and locations that were instrumental in obtaining food" (Call & Tomasello, 1994, p. 312).

Call and Tomasello (1994) then tested the orangutans' comprehension of human pointing. E1 entered, retrieved all three boxes from their cages, moved with the boxes behind an occluder, and baited one of the boxes. E1 then returned the

boxes to their cages, pointed to the baited container in view of the subject, and departed. E2 arrived and, as before, situated himself behind the middle cage and waited for the subject to point to one of the boxes. Chantek pointed to the baited container on 33 of 63 trials, which was significantly above chance (chance = 33%), whereas Puti pointed to the baited container on only 20 of 63 trials (32% correct, or essentially chance). Neither subject improved over three sessions of 21 trials each. Both subjects exhibited some perseveration by pointing to the box that had been baited on the previous trial.

In their final experiment, Call and Tomasello (1994) assessed the influence of the state of observer visual attention on the pointing of their subjects. During baseline trials, an experimenter filled each of two glasses with different amounts of juice, displaced the glasses on a platform so that they were 60 cm. apart. When the subject pointed to one of the glasses, the experimenter delivered the juice to the subject. On test (probe) trials, the experimenter waited 30 seconds before delivering the juice to the subject and during this interval adopted one of four postures: (a) remained seated, facing subject, eyes open, (b) remaining seated, facing subject, eyes closed, (c) walking to a corner of the room and facing away from subject, and (d) exiting the room. Chantek pointed far more when the experimenter was facing him with his eyes open, compared to the other three conditions. Puti, in contrast, pointed equally often during the eyes open and eyes closed conditions, but pointed much less when the experimenter was

facing away or out of the room.

In their general discussion, Call and Tomasello (1994) concluded that Chantek, by virtue of his intimate rearing with humans, "had come to understand human beings as intentional agents who have voluntary control over their behavior and attention" (p. 315). What the authors appear to mean by understanding others as intentional agents is an ability to (a) discriminate states of visual attention and (b) manipulate visual attention in others, although it should be said that the authors do not adequately define "attention," "intentional agents," etc. Presumably, "visual attention" is a hypothetical construct that is correlated with observable visual orienting behavior. Thus, for example, an observer facing away from a signaler cannot be "attending" to the signaler. It is clear from their later publications that Call & Tomasello (e.g., 1996; Tomasello & Call, 1997) believe that some apes, including humans, deploy their gestural and visual orienting behaviors on the basis of a discrimination of the "intentional" states of other social agents (i.e., organisms make inferences about the goals and other epistemic states of other organisms and these inferred goals are used to predict the behavior of others). Call and Tomasello (1994) attribute these capacities to exposure, early in development, to particular patterns of reinforcement in joint attentional contexts, such as is experienced by human children. In later writing, Call and Tomasello (e.g., 1996; Tomasello & Call, 1997) seem to posit a sort of joint attentional rubicon, across which an organism (ape or human) engages in discrimination of and

manipulation of intentional states in others, by virtue of rearing by humans (Locke, 1999, p. 339, refers to this as a kind of "psychological alchemy"). Such an organism is, in their view, "enculturated."

An experimental study of pointing by three chimpanzees was reported by Leavens, Hopkins, and Bard (1996). The impetus for their study was the observation of apparent pointing behavior by an adolescent male chimpanzee named Clint. Clint had been administered a variety of matching-to-sample tasks via a computerized test system that used an automatic reinforcement dispenser to deliver peanuts or grapes to Clint when he made a correct response (i.e., when he selected a comparison stimulus that matched a sample stimulus). The reinforcement dispenser occasionally failed to deliver the food to a delivery tube mounted on the computer cart, sending the grape or peanut, instead, into the corridor outside Clint's reach. In this context, he was observed to extend his index finger toward the fallen food in the presence of an experimenter, while alternating his gaze between the fallen food and the experimenter, and occasionally vocalizing (thus, apparently exhibiting all the hallmarks of intentional communication). Leavens et al. (1996) videotaped Clint for over 18 hours as he performed matching-to-sample problems, noting all finger extensions directed outside his cage and whether these finger extensions were exhibited in the presence or absence of human observers. In the course of coding the videotapes, it became apparent that both of Clint's female cagemates, Flora and Anna, also exhibited finger extensions outside the cage

mesh from the first videotaped session.

The most significant finding in this study was that of the 256 finger extensions recorded, 254 were exhibited in the presence of a human observer; thus, the finger extensions were subject to the presence of an observer. Because the camera was oriented in such a way as to capture Clint's behavior and because his work with the computer apparatus kept him in a fairly constant position, visual orienting behavior was only recorded for Clint. Clint exhibited gaze alternation (defined as looking successively at a social agent and at an object, usually food) during 76% of his finger extensions and vocalized during 24% of his finger extensions (it should be noted that reliability estimates for both gaze alternation and vocalizations were relatively modest: Cohen's Kappas were .55 and .52 for gaze alternation and vocalizations, respectively). In those few instances when Clint exhibited finger extensions in the presence of someone other than Leavens (14 episodes), the probability of reinforcement was lower than in the presence of Leavens (p = .357 and .514, respectively). Clint's behavior in the presence of people other than Leavens varied in accordance with this difference: He exhibited only slightly more gaze alternation (during 79% of finger extensions), but substantially more vocal behavior (during 55% of finger extensions) when gesturing in the presence of people who were less attentive or responsive to his communicative behavior. Finally, Leavens et al. (1996) reported that the three chimpanzees exhibited finger extensions with their index fingers during 37% of their

extensions (86 of 233 finger extensions for which hand use could be assessed), and that index-finger extensions were substantially associated with the right hand (18% with the left hand, 67% with the right hand).

On the basis of this evidence, Leavens et al. (1996) concluded that the chimpanzees were pointing and, because these subjects were not raised in the kind of intimate, culturally rich manner in which language-trained apes are generally reared, that "enculturation" is not necessary for the development of pointing in chimpanzees (contra Call & Tomasello, 1994). Because these subjects frequently pointed with the index finger, Povinelli and Davis' (1994) claim that chimpanzees don't point with the index finger was therefore refuted. Leavens et al. (1996) speculated that the barrier to directly grasping fallen food (the cage mesh), combined with established histories of profligate food provisioning by humans, established a problem space unique to captive (as compared with feral) apes. They noted the apparent parallels between the contexts in which these apes pointed and the contexts in which human infants begin to point: Infants can see objects of interest, but due to inherent limitations on their locomotor capacities, and given their histories of object- and food-delivery by older caregivers, come to discern their caregivers as means in the solution of particular problems in the acquisition of otherwise unreachable objects.

Leavens and Hopkins (1998; Hopkins and Leavens, 1998) reasoned that if the foregoing speculations were correct, then pointing should be far more common among captive

chimpanzees than heretofore recognized. They assessed the communicative behaviors of 115 chimpanzees, ranging in age from 3 to 56 years. In this experiment, one experimenter (E1) placed one half of a banana on the ground one meter from either the left or right wall (defined with reference to a chimpanzee facing out of the cage) of each subject's cage, then departed. A second experimenter (E2) arrived after approximately 30 seconds, faced the subject, and recorded all apparent gestural behavior, vocal behavior, and whether or not subjects exhibited gaze alternation (looked successively between the banana and E2). If the subject exhibited either gestures or vocalizations, they were immediately rewarded with the banana. If, after approximately 30 seconds, the subject did not exhibit gestures or vocalizations, then they were given the banana.

Of the 115 subjects, 78 exhibited some kind of gesture (68% of subjects). Of the 78 subjects who gestured, 16 (21%) exhibited food begs (hand held toward E2 in a supine, usually "cupped" posture), 42 exhibited pointing with the whole hand (54%), six exhibited pointing with the index finger (8%), five exhibited both food begs and points (6%), and nine exhibited a variety of other apparently communicative behaviors, including presentation of the rump, a tickle solicit, three apparent attempts to barter food scraps for the banana, two cage-banging responses, a lip pout (protrusion of lower lip), and a repeated biting of the right thumb (12%). Subjects were categorized on the basis of whether they (a) both vocalized and gestured, (b) gestured only, (c) vocalized only, or (d) neither vocalized

nor gestured. Strikingly, 100% of the 27 subjects who both vocalized and gestured also exhibited gaze alternation between the banana and E2. Eighty percent of the 51 subjects who gestured only also exhibited gaze alternation, as did 75% of the 8 subjects who vocalized only. Of the 29 subjects who neither vocalized nor gestured, only 41% exhibited this gaze alternating behavior. Because pointing was the most common gesture elicited (68% of gestures included pointing), Leavens and Hopkins (1998) concluded that pointing was a commonly exhibited gesture at their study site (the Yerkes Regional Primate Research Center, in Atlanta, GA). Leavens and Hopkins also concluded that subjects were not reaching for the (obviously unreachable) bananas because (a) pointing was associated with high levels of gaze alternation, as were other unambiguously communicative gestures, such as food beg responses and (b) subjects' hand use while pointing was random with respect to side of banana placement; that is, the chimpanzees were as likely to use the hand contralateral to the side of food placement as the hand ipsilateral to the side of food placement, and this is inconsistent with patterns of reaching in other experimental contexts, in which reaching to laterally presented food items is typically exhibited with the ipsilateral hand by humans and apes (Welles, 1976).

In a separate report of hand use while gesturing, using the same data set reported above, Hopkins and Leavens (1998) reported that chimpanzees exhibited an overall right-hand bias in gestures. This was particularly evident for the food beg gesture, a well-described, species-typical gesture

(e.g., van Lawick-Goodall, 1968; Plooij, 1978; Teleki, 1973): of the 19 food begs recorded, 16 (84%) were exhibited with the right hand. Strikingly, individuals who vocalized while gesturing were more likely to use the right hand, compared to individuals who did not vocalize while gesturing. This is suggestively similar to the case of hand use while gesturing by humans: Humans are predominantly right-handed in their gestural behavior and even more right-handed when they vocalize while gesturing or exhibiting other unimanual activities (Dalby, Gibson, Grossi, & Schneider, 1980; Hampson & Kimura, 1984). This phenomenon has been taken as evidence for the "overflow hypothesis" of Kinsbourne and Hicks (1978). According to this hypothesis, spreading electrochemical activation from one functional area of the cerebral cortex (e.g., Broca's area while speaking) influences adjacent neural tissue (e.g., primary motor cortex controlling the limbs and hands), resulting in a lower threshold for motoric activity. Hopkins and Leavens (1998) suggested that (a) there may be a functional asymmetry in chimpanzee cerebral hemispheres that is related to intentional communication and (b) an overflow mechanism like that hypothesized by Kinsbourne and Hicks (1978), and linking vocal and gestural behavior, might be evident not only in humans, but in chimpanzees as well. Hopkins and Leavens (1998) concluded that neural imaging technology will be of use in testing these hypotheses in the near future.

Krause and Fouts (1997) reported pointing by two sign-language-trained chimpanzees, Moja and Tatu. They administered two experiments. In the first experiment, E1

baited one of two containers placed five meters apart and far enough to prevent the subjects from reaching into the containers and then departed. E2 then entered, turned on the videocamera, and sat facing away from the subjects. E2 turned around only after the subject exhibited some audible signal (including "bronx cheers," hand claps, cage-banging, foot stomp, linguistic signs performed with sufficient force to make a distinct sound, and combinations of these). After turning in response to an audible signal, E2 fixed his gaze on the subject. When the subject pointed to one of the two containers, E2 arose and delivered the indicated food to the subject. Each subject received 50 trials over a 37-day period.

Strikingly, audible ("attention-getting") signals were emitted by both subjects prior to pointing on 100% of the 100 trials (50 trials each). On 99 of the 100 trials, pointing was exhibited after E2 had established eye contact. Gaze alternation between one of the containers and the experimenter was exhibited during 97 of the 100 trials. The subjects pointed to the baited container on 99 of the 100 trials. In this study, 72% of the points emitted with the left hand were with the index finger (the remainder being with the whole hand) and 92% of the points emitted with the right hand were with the index finger. Krause and Fouts (1997) argued that the pointing was communicative in function (i.e., that the finger extensions did not constitute "reaches" toward the food).

Krause and Fouts' (1997) second experiment was designed to assess the accuracy with which these two chimpanzees

pointed. Four containers were arranged such that there were two placed on the ground 1.2 meters apart with the other two containers placed 1.2 meters above the lower two. Each subject received 40 trials (80 trials total), over a 34-day period. After one of the containers had been baited by E1, E2, the interactor, entered the room and responded to the chimpanzees' points. After delivering the food to the chimpanzee, E2 recorded on a piece of paper which box had been pointed to by the chimpanzees, left the slip of paper in the food bowl, and delivered the bowl to E1, who recorded this information on a cumulative data log. A third individual, the observer, also coded the target location of each point from videotape. Reliability between observers and interactors was high: Cohen's kappa = .83.

Krause and Fouts (1997), found that the percentage of trials scored as correct (chimpanzee perceived as pointing to the baited box) was significantly above chance for both chimpanzees and for both the observer and the interactant. In this experiment, all points observed were exhibited with the index fingers. As Krause and Fouts noted, this second experiment both required and elicited greater precision in the form of pointing (i.e., much more pointing with the index finger), compared to the first experiment, though it remains unclear which aspects of the differences between the two experiments influenced the number of fingers extended while pointing by these two chimpanzees.

In a recent study of long-term memory for object location, C. Menzel (1999) reported on the pointing behavior of Panzee, a female, language-trained chimpanzee housed at

the Language Research Center at Georgia State University. In brief, over a period of 268 days, an experimenter presented 34 trial-unique experimental trials in which he hid, in full view of Panzee, food or nonfood objects in the woods outside Panzee's outdoor enclosure, confined to an area of approximately 160 square meters. Over this period of 268 days, there were 57 days during which an item was hidden in the woods and 211 days during which no item was hidden. In the ensuing days, caregivers recorded whether Panzee "solicited" their attention and directed them to the woods in which the objects were hidden. These caregivers were "uninformed" in the sense that they did not know whether there were any hidden items on any given day, though they did know that objects would be sporadically hidden. Panzee pointed to the location of a hidden object on 34 of the 57 days in which objects were hidden in the woods (i.e., on some days, though objects were hidden, Panzee did not direct the attention of the caretakers to these objects). In contrast, during the 211 days in which no items were hidden, Panzee exhibited pointing on only 3 days. Latencies from the time Panzee observed an item being hidden to the time that she captured and re-redirected the attention of one of the caregivers to that hidden item ranged from .03 hours to 304.4 hours.

More recently, Whiten (2000) reported the effects of the epistemic status of an experimenter on the pointing behavior of Panzee (the experiment used three chimpanzee subjects, Panzee, Austin, and Sherman, but only results from Panzee were reported). It is unclear from a preprint of

this chapter precisely how many trials of each type were administered (baseline, experimental, and control) as it is stated that "Panzee received 100 . . . baseline trials" (p. 150) and that 10 experimental trials were "interspersed amongst the last 80 of these baseline trials" (p. 150) and an unspecified number of control trials was also "interspersed amongst the last 80 baseline trials" (p. 151); probably 10 control trials were administered. For the following description it will be assumed that Panzee received 120 trials, of which 100 were baseline trials, 10 were experimental trials, and 10 were control trials.

The first 20 trials were baseline trials which unfolded in the following way. A Hider entered the room outside Panzee's cage holding an "attractive" food item (p. 150), grasped a key hanging in front of the cage, used the key to open one of two boxes placed a meter apart, put the food in the box, locked the box, returned the key to its hook, and departed. A minute or two later, the Helper entered the room, stood between the two boxes, looked at Panzee and said "Okay, Panzee." Panzee pointed consistently to the baited box during these baseline trials. In the 10 experimental trials, the procedure was altered as follows: the Helper, not the Hider, entered with food, took the key, used the key to unlock one of the boxes, baited the box with the food, returned the key to the hook, and then departed. A minute or two later, the Hider entered, took the key, and put the key in one of seven different locations (three locations were used twice), then departed. Thus, the epistemic state of the Helper was such that he was ignorant of key location.

In each of the first nine experimental trials, Panzee pointed to the location of the key on the return of the Helper to the room. Because Panzee also pointed to the key during 13 of the 100 baseline trials, Whiten (2000) noted that it was ambiguous whether Panzee was responding to the epistemic status of the Helper (ignorant of key location) or encouraging the Helper to act on a "useful part of the environment" (p. 151).

An unspecified number of control trials (assumed here to be 10) was conducted in which the Helper entered the room, unlocked both boxes (leaving the padlocks open), placed the key in a new location, then departed. The Hider then entered, baited one of the boxes, locked both boxes, and departed without touching the key. Thus, in these control trials, the key was displaced, but the epistemic status of the Helper was such that he knew the location of the key, having placed it himself. During "all but 2 trials" (p. 151) Panzee pointed to the baited box and not the key location. Whiten (2000) interpreted this finding to indicate that Panzee was responding (pointing to either the baited box or to the key) on the basis of the epistemic status of the Helper. Whiten speculated that intense exposure to humans had enhanced Panzee's ability to discriminate epistemic states in others (this interpretation is congruent with the position of Call & Tomasello, 1994, 1996, on the effects of rearing history on chimpanzees' cognitive performance).

CHAPTER 3

RATIONALE FOR THE PROPOSED RESEARCH

The seven experimental studies discussed in the previous chapter are summarized in Table 3. Perusal of Table 3 reveals that no experimental study of pointing by apes has failed to find audience effects on the pointing, when such audience effects have been designed into the study. Effects of observers on pointing reported to date include observer presence (Call & Tomasello, 1994; Leavens et al., 1996), observer visual attention (Call & Tomasello, 1994, Krause & Fouts, 1997), differential histories of reinforcement associated with different observers (Woodruff & Premack, 1979), and, possibly, epistemic state of an observer (Whiten, 2000). However, despite the near ubiquity of these

Table 3. Summary of findings from experimental studies of pointing in apes.

Study	*N*	Audience effects?	Index finger?	Language-trained?
Woodruff & Premack (1979)	4	Y	N	N
Call & Tomasello (1994)	2	Y	Y(1)	Y(1)
Leavens, Hopkins, & Bard (1996)	3	Y	Y(3)	N
Krause & Fouts (1997)	2	Y	Y(2)	Y(2)
Leavens & Hopkins (1998)	53	-	Y(6)	N
Menzel (1999)	1	-	Y	Y
Whiten (2000)	1	Y	Y	Y

Notes. "Y" indicates "yes," "N" indicates "no." Numbers in parentheses refer to the number of individuals exhibiting either index-finger pointing or who were language-trained. Dashes indicate that no audience effects were assessed.

audience effects, they have been reported in exceedingly small samples ranging from one to four animals. No large-scale assessment of audience effects on pointing by apes has yet been performed. For this reason, Experiment One, reported below, is designed to assess the influence of an observer on the gesture rates of chimpanzees in each of four conditions: (a) neither food nor experimenter present, (b) experimenter, but not food present, (c) food, but not experimenter present, and (d) both food and experimenter present. Experiment 3 was designed, in part, to assess the influence of the presence of an observer on the propensity to gesture across two conditions: observer present and observer absent, with food present throughout.

The second salient pattern evident in Table 3 is that almost all experimental studies of pointing by apes report some pointing with the index finger, thus refuting the claims by Petitto (1988), Povinelli and Davis (1994), and others (e.g., Butterworth & Grover, 1988; Werner & Kaplan, 1963), to the contrary. Nevertheless, it remains true that pointing with the index finger is exhibited at far higher frequencies by language-trained apes than by apes who have not been language-trained (Leavens & Hopkins, 1999); these latter apes tend to point with their whole hands. Therefore, it appears that rearing history may exert an influence on the number of fingers extended while pointing. However, as noted by Krause and Fouts (1997), who found both whole-hand and index-finger pointing in their two chimpanzee subjects, it remains unclear which aspects of the stimulus array may influence the number of fingers extended while

pointing in apes. Among the possible factors discussed by Krause and Fouts (1997) are the relative distances between (a) the signaler and the desired object, (b) the relative distances between baited containers, and (c) the number of containers present in the stimulus array. In an unpublished study with 20 chimpanzee subjects, Leavens and Hopkins assessed the effects of size and distance of food items on gesture use. Leavens and Hopkins found no influence of either size or distance on the propensity of the chimpanzees to gesture, nor was there any effect of the manipulation on gesture type (i.e., subjects did not point more or less as a function of size or distance of the food items).

Pointing with the index finger characterized 37% of the 233 points for which Leavens et al. (1996) could confidently assess either which finger was extended or how many fingers were extended. Yet, in a large-scale survey of the colony of chimpanzees at the Yerkes Regional Primate Research Center (YRPRC), Leavens and Hopkins (1998) reported that only six chimpanzees pointed with the index finger out of 53 chimpanzees who pointed. Because the latter study involved placing half of a banana on a relatively homogeneous surface (the corridor floor) a full meter from each subject's cage, whereas the study by Leavens et al. (1996) involved either single peanut kernels or grapes or random clusters of these food items which had fallen from just a few centimeters to approximately 50 centimeters from these subjects' cage, it is possible that the relative dispersion or spread of the food array may influence the structure of pointing by chimpanzees. Therefore, Experiment

2 was designed to manipulate the relative dispersion of an array of food, placing a single grape in the context of an array of six peanuts, and varying the distance between these seven food items.

Finally, Experiment 3 was designed to assess the influence, if any, of whether a banana was visible or hidden, upon the arrival of an experimenter. There were two questions here: (a) will chimpanzees modify their communicative repertoires as a function of whether the experimenter can or cannot see a banana, and (b) how good are chimpanzees at communicating about hidden objects? The impetus for asking the first question derived from a study of two-year-old children by O'Neill (1996). O'Neill (1996) demonstrated that more toddlers in her study gestured when their mother was ignorant of object location (had not seen the baiting event), compared to a condition in which the mother was knowledgeable about the location of an object (had seen the baiting event) (O'Neill, 1996). A slightly different question was asked here: Do chimpanzees alter their communicative repertoire as function of whether a food item is visible or hidden? The reasoning is as follows: if chimpanzees adjust their communicative behaviors in accordance with what an observer can or cannot see, this can be taken as evidence that they discriminate the visual perspective of others. (Since this experiment was designed and conducted, a recent article by Hare, Call, Agnetta, & Tomasello, 2000, presented strong evidence that chimpanzees discriminated between (a) food items which could be seen by a dominant chimpanzee and (b) food items which could not be

seen by a dominant chimpanzee. Thus, under some experimental conditions, chimpanzees do discriminate what a chimpanzee observer can or cannot see.)

With respect to the second question, how well do chimpanzees communicate about hidden objects, E. Menzel showed that young chimpanzees were quite skilled at communicating about various aspects of hidden food, including food location, food quantity, and food type (e.g., E. Menzel, 1971, 1973, 1974). But these chimpanzees were studied for years, from their juvenile periods to early adolescence, during which period they had been tested in many different experimental trials involving hidden and visible food. E. Menzel never observed pointing behavior among these chimpanzees; if anything, the overt behavioral accompaniments of their searching behaviors tended to decrease in number and intensity with the passage of time (E. Menzel, 1974, p. 130).

As reviewed above, pointing to hidden food or tools has been reported for apes who have been raised in very intimate association with humans (Call & Tomasello, 1994; Krause & Fouts, 1997; C. Menzel, 1999; Whiten, 2000; Woodruff & Premack, 1979). These studies all involved repeated presentations of a variety of different trial types to relatively few subjects (ranging from 1 to 4). The procedure adopted here was to ask how competent were chimpanzees who had not been raised in home-like environments at communicating about hidden objects? The procedures employed in Experiment 3, and the other two experiments reported here, rely exclusively on first-trial

data presented to a large number of chimpanzees.

CHAPTER 4

CONSTRAINTS ON THE PROPOSED RESEARCH

The overall procedural emphasis of this experiment and the experiments described below was on "first-trial" performance of chimpanzees. Because the emphasis was on assessing the use of communicative behaviors by these chimpanzees, under various experimental circumstances, the general method combined elements of both observational and experimental approaches (Shaughnessy, Zechmeister, & Zechmeister, 2000). An attempt was made, in all cases, to employ relatively "naturalistic" experimental paradigms. This does not mean that the experimenters attempted to mimic any of the parameters of chimpanzees' natural habitats; rather, this means that the experimenters attempted to conduct these procedures with a minimum of departure from the routine circumstances of these captive chimpanzees' daily lives. In accordance with this general principle of minimalist intervention, numerous sources of uncontrolled variability will have entered the results, some of which sources of uncontrolled variability are discussed here.

The Great Ape Wing at the YRPRC consists of five sub-wings termed "A-wing," "B-wing," "C-wing," "D-wing," and "E-wing" (henceforth, A, B, C, D, and E). A through D are arranged in a contiguous series of identically sized cages, each of which has both an indoor and outdoor section. The dimensions of the indoor sections of these cages are 213 cm. high, 229 cm. wide, and 213 cm. deep. The dimensions of the

outdoor sections are 213 cm. high, 229 cm. wide, and 335 cm. deep. There are corridors that run parallel to both the inside and outside sections of the cages in A through D. The corridor along the outside sections of the cages is 234 cm. wide, and the corridor along the inside sections of the cages is 236 cm. wide. Perpendicular to the long axis of these cages are short corridors that bisect this long line of cages at two junctions: (a) between A and B and (b) between C and D. Relative to A through C, D is offset at an angle of approximately 10 degrees. The fifth wing, E, is arranged perpendicular to the other wings, with one end forming the junction of the two arms of an "L" with A, and comprises much larger cages in which are housed relatively large groups of chimpanzees. The dimensions of the inside sections of the cages on E are 290 cm. high, 305 cm. wide, and 396 cm. deep. The dimensions of the outside sections of these cages are the same as the inside sections. The corridor along the outside sections is 267 cm. wide, and the corridor along the inside sections is 295 cm. wide. All cages are separated on the inside by concrete walls, some of which have steel gates which can be opened and closed. All cages on the outside are separated by a combination of concrete wall and cage mesh of varying diameter, allowing visual access to other chimpanzees. The inside-facing and outside-facing walls of the inside and outside cage sections, respectively, are comprised of stainless steel mesh with a diamond-shaped pattern of approximately 2.54 cm. sides.

The layout of the chimpanzee cages at the YRPRC

presents considerable difficulty in controlling the precise time at which subjects become aware of the arrival or impending arrival of the experimenters. If, for example, a chimpanzee is located towards the middle of a long corridor, then an experimenter has to traverse a relatively long distance and numerous cages housing other chimpanzees, who often vocalize, throw feces, or otherwise react to the passage of the experimenter. Thus, the subject will usually have information heralding the arrival of an experimenter before the experimenter is in the precise positions called for in the various experimental procedures described below. The latency of this "advance notice" relative to the time the experimenter is in position, will vary, in part, as an irregular function of how far a particular subject is from one or the other end of the long corridors. A decision had to made as to whether it was more desirable to precisely control the timing of the presentation of an experimenter to each subject or to continue with the experiments in the face of uncontrolled variation in the latencies between the visual and auditory cues heralding the impending arrival of an experimenter and the time the experimenter was in position. Given the circumstances, there are only two methods to physically control this latency. First, one could move all animals except the subject to the outside enclosures. At THE YRPRC, there is no more disrupting activity than to try to move, en masse, all chimpanzees either to the inside sections or the outside sections of their cages. The level of disruption resulting from this approach obviates its use in the experiments described

below. Second, one might construct an apparatus that obscures the experimenter from the chimpanzees intervening between the start position of the experimenter and the subject's cage. This course was deemed undesirable because the novelty and necessary size of such an apparatus conflicts with the principle of minimal intervention, in accordance with which these experiments were designed. For these reasons, most chimpanzees in the experiments described below have uncontrolled advance warning of the arrival of the experimenter.

These physical environmental factors also influence the validity with which it can be claimed that trials are "first-trial" exposures, insofar as cagemates and near-neighbors of a specific subject will have had an opportunity to observe the administration of the experimental conditions to that subject and any other subjects who were tested before them. Thus, it is not possible to rule out observational learning within the context of these experiments as a factor in the behavioral responses. However, such observation is most pertinent to the findings of Experiment 3, in which subjects' responses could be categorized as being either correct or incorrect. As described in the method section for Experiment 3, internal checks were performed of the possibly facilitating effects of being the second or later subject in a cage to be administered the task. Checks were performed on whether being second or later in a cage to see a task had any influence on performance or propensity to gesture.

A third methodological issue relates to the position of

the subjects relative to the placement of the videocamera, the food items employed to elicit communicative behaviors, and the position of the experimenter. In the three experiments reported below, the chimpanzees were free to move between and within the inside and outside sections of their enclosures. Any effort to control the position of the subjects in their cages was deemed to be either so disruptive or so time-consuming that it would have been impossible to conduct these experiments in the time available. As a consequence, the amount of time each subject appears in the video record varies considerably across subjects. This lack of control of the spatial position of the chimpanzees introduces uncontrolled variability in both the distances between subjects and both food and experimenters, and the angles between these three elements. This will have had a direct effect on the designation of a number of behavioral measures (described in more detail below) such as whether subjects looked successively between a bucket and an experimenter and whether the orientation of a particular gesture was directed toward a banana or a bucket rather than an experimenter. This means that classification of gaze behaviors and gestural orientations is based on a judgment by an observer that is not defined in terms of a constant angle between fixed elements, because this angle will vary across subjects according to their position in the cage. Classification of the orientation of a gesture as being either person-directed or object-directed, for example, is not defined here by a constant angle or range of angles between the signaler's arm

and the putative targets of the gestures; rather, a categorical judgment is made by the observer as to whether the gesture is directed at the observer, at a food item (or bucket), or at neither the observer nor the food item. To counter this consequence of the lack of control over subjects' spatial position, interobserver reliability estimates were performed throughout the following experiments on measures of gesture orientation and gaze alternation.

CHAPTER 5

EXPERIMENT 1: AUDIENCE EFFECTS ON GESTURES

The purpose of the present experiment was to evaluate the influence of observer and food presence on the propensity to gesture by chimpanzees.

Method

Subjects

Subjects were 35 chimpanzees (*Pan troglodytes*, 15 females) housed at the Yerkes Regional Primate Research Center (YRPRC), at Emory University, Atlanta, GA. All subjects were treated in accordance with the ethical standards of the American Psychological Association (American Psychological Association, 1992). The history of each subject's participation in studies of gestural communication is listed in the Appendix.

Subjects were selected from A and D of the Great Ape Wing at YRPRC, because the cages in these sections were relatively free of secondary reinforcing bars, which tend to obscure behavioral observation (these reinforcing bars were originally emplaced to contain gorillas). Subjects were observed in random order within wings: all subjects were randomly assigned a number between 0 and 1 and then listed in ascending order of this random number. Testing occurred first in A (on December 28, 1999) then in D (on December 30, 1999).

Materials

The experimental arrangement is depicted in Figure 2.

A videocamera was placed to each subject's right, approximately 1.5 m from the cage (this was the maximum possible distance, due to the width of the corridor), and oriented to encompass in the field of view as much as

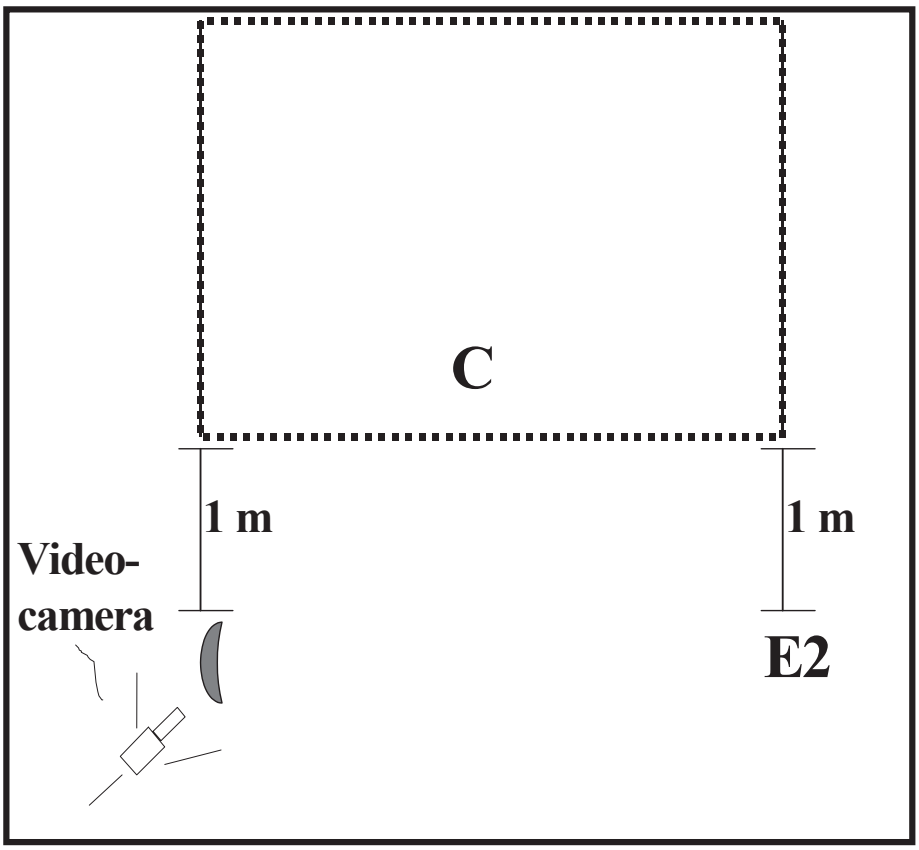

Figure 2. Experimental arrangement for Experiment 1. "C" refers to the subject, "E2" refers to the second experimenter. The grey crescent depicts a banana. Drawing not to scale.

possible of the interior of each cage. Due to limitations in the ability of the experimenters to capture the entire cage in the field of view the specific angle at which the camera was oriented was adjusted on each trial in correspondence with the level of the substrate on which each subject began each trial. If subject began a trial on the

floor of the cage, the angle of the camera would be slightly lower (more acute, relative to the plane of the floor) than if a subject began a trial on a shelf, one meter above the floor. Thus, the angle of view differed slightly across subjects, depending upon their initial position, in vertical dimension, at the start of each trial.

Procedure

Subjects were administered four conditions in invariant order: (a) neither food nor experimenter present, (b) experimenter present, no food, (c) food present, no experimenter, and (d) both food and experimenter present; each sequence of four conditions comprised one trial. The duration of each condition varied across subjects, but was held to a minimum of 15 seconds for all subjects in all conditions (Table 4). The total time that chimpanzees were visible on tape was 36.52 minutes from a total observation period of 49.57 minutes (i.e., over all four conditions, the 35 subjects were on camera a total of 74% of the time).

The procedure was as follows: Experimenter 1 (E1) positioned the videocamera and announced "Start" as he departed. After a short interval, Experimenter 2 (E2) was signaled by a hand wave to approach the cage. E1 attempted to ensure that the arrival of E2 coincided with an elapsed time of 15 seconds from the "start" signal, but this proved impossible in the majority of cases, for reasons discussed above, so a minimum interval of 15 seconds duration for each condition was adopted.

When E2 reached the position indicated in Figure 2, he announced "Here." E2 looked at the subject, but did not

Table 4. Descriptive statistics on the durations, in seconds, of each condition and the durations subjects were visible to the camera (N = 35). Condition 1: neither experimenter nor food present. Condition 2: experimenter, but not food present. Condition 3: food, but not experimenter present. Condition 4: both food and experimenter present.

	Condition			
	1	2	3	4
Duration of condition				
Mean	23.9	20.6	22.6	17.8
SD	2.7	1.8	2.1	2.5
Minimum	18.0	15.0	18.0	15.0
Maximum	29.0	25.0	29.0	27.0
Duration subjects on camera				
Mean	19.8	15.9	16.5	10.5
SD	7.6	7.2	7.7	8.2
Minimum	0.0	0.0	0.0	0.0
Maximum	29.0	24.0	29.0	27.0

respond to any apparent communicative behaviors. The interval between the "start" and "here" signals comprised Condition 1 (neither food nor experimenter present). After a minimum of 15 seconds, E1 gave a visual signal to E2 to depart. Roughly coincident with this signal, as E2 departed, E1 began a very rapid approach, simultaneously placing the banana as indicated in Figure 2 and announcing "food," followed by a rapid departure (E1 avoided all eye contact with the subjects). The interval between the "here" of E2 on arrival and the "food" signal defined the duration of Condition 2 (experimenter, but not food present). After a short (variable) interval, E1 signaled E2 to approach the cage. When E2 arrived in position (same position as in Condition 2), he announced "here." The interval between the "food" signal and the second "here" signal defined the

duration of Condition 3 (food, but not experimenter present). After a minimum interval of 15 seconds, E1 announced "end." The interval between the second "here" signal of E2 and the "end" signal comprised the duration of Condition 4 (both experimenter and food present). Immediately after the "end" signal, either E1 or E2 delivered the banana to the subject.

Behavioral Measures

Gestural responses are defined as in Table 5. A distinction is made in Table 5 between object-directed and person-directed gestures. To qualify as a person- or object-directed gesture, arm or finger extensions were categorized with respect to two planes of reference, one plane constituting the bottommost substrate (i.e., the floor) and the other perpendicular to both this substrate and the axis of the cage mesh; these are termed the "horizontal" and "vertical" planes, respectively. In the horizontal plane, in Experiment 1, the locations of a banana and the experimenter were constant, whereas the position of the subject was uncontrolled. For each trial, the position of the chimpanzee was taken to be the focus of an angle between the terminal points of the left and right walls of the subject's cage. A dichotomous judgment was made with respect to whether the orientation of a putative gesture was more to the subject's right side (toward the banana or videocamera) or more toward the subject's left side (toward Experimenter 2). In the vertical plane, again, the positions of the subjects varied, both in height and in distance from the cage mesh. In general, arm or hand

Table 5. Response categories for Experiments 1, 2, and 3.

Object-directed gestures	
Whole-hand point	Hand is oriented towards banana (or bucket), palm is oriented either vertically (with thumb at top) with respect to the substrate, or in a pronated position, or between these two extremes. At least two fingers are extended.
Index-finger point	As for whole-hand point, but only index finger is extended.
Food beg1	Hand is oriented towards banana (or bucket), palm is supinated. Often, fingers adopt a "cupped" posture.
Person-directed gestures	
Hold hand out	Identical to Whole-hand point, except that orientation is toward the experimenter rather than the banana or bucket.
Food beg2	Identical to Food beg1, except that hand is oriented towards the experimenter rather than the banana or bucket.
"Barter attempt"	Apparent attempt to trade some items for food presented outside cage: for example, pushing out peanut shells while looking back-and-forth between an unreachable banana and an experimenter.
Other	Any other behavior that appears communicative, but do not fit easily into the above categories.

orientations that seemed to be directed in the vertical plane within approximately 20 degrees above or below either the banana or the experimenter's thorax were categorized as being experimenter- or banana-directed.

In addition to gestural responses, visual orienting behavior during Condition 4 was defined in dichotomous terms as either constituting successive looking between the videocamera (or banana) and E2 (gaze alternation) or not constituting successive looking between the videocamera or banana and E2. Responses were recorded by E2 on a data sheet during his presence in Conditions 2 and 4. The present author, who was E1 in all trials, independently coded these behaviors from the videotaped record.

Reliability

Reliability was assessed by comparing the observations from videotape with those performed by E2 in Conditions 2 and 4. Included in the reliability assessments were those individuals who were visible on tape throughout the condition of interest and those individuals who were not visible on videotape for the entire duration of the condition of interest, but for whom both E2 and the separate observer registered agreement that the subject did gesture (Conditions 2 and 4), vocalize (Condition 4 only), or exhibit gaze alternation between the banana and E2 (Condition 4 only). Excluded from reliability assessments were those individuals who were not visible on videotape for the entire duration of the condition of interest and for whom E2 had registered a non-response in the categories of gesture, vocalization, and gaze alternation; this, because it was therefore impossible to verify the absence of a behavior in the interval of interest. In Condition 2, reliability on gesture type, including 23 subjects, was calculated as Cohen's kappa = .78; the corresponding

analysis for Condition 4, including 16 subjects, was .80. Agreement as to whether subjects vocalized was 100% in Condition 4 (due to a failure to communicate instructions clearly, recording of the presence or absence of vocalizations in Condition 2 by E2 was erratic--therefore agreement was not assessed in Condition 2; data on the presence or absence of vocal behavior for Condition 2 were taken from the videotape, not from the original data sheets). Agreement as to whether or not subjects alternated their gaze between the banana and E2 in Condition 4, including 26 subjects, was Cohen's kappa = .64. Cohen's kappa corrects for agreement by random chance: kappas between .4 and .6 are considered fair, between .6 and .75 good, and above .75 excellent (Bakeman and Gottman, 1986).

Analyses

To test the null hypothesis that gestures were randomly distributed in time, Cochran's Q was employed. This statistic is appropriate for data which can be dichotomously categorized (i.e., "success" and "failure") over more than two levels of an independent variable which involves use of the same or related samples in each level (Siegel, 1956); the analogous test for nominal data over two levels of an independent variable is McNemar's test for symmetry. Alpha was set at .05 and tests were two-tailed.

Results

Observer and Food Effects on the Propensity to Gesture

Of 35 subjects, 17 gestured in this study. Table 6 lists the 12 individuals who gestured on camera in Experiment 1. An additional five chimpanzees gestured off

camera. Time 1 refers to the time that E2 arrived in position between Condition 1 and Condition 2. Time 2 refers to the time E1 declared "food," which marks the division between Condition 2 and Condition 3. Time 3 refers to the time that E2 arrived in position between Condition 3 and Condition 4. Figure 3 depicts the temporal distribution of the first gestures exhibited by these 11 individuals, plus the second gesture by one subject, Carl. Table 7 lists all individuals who gestured and in which condition(s) each individual gestured, including data from those individuals who did not gesture on camera. It should be noted that

Table 6. Individuals who gestured on camera in Experiment 1. Time 1 refers to the transition between Condition 1 and Condition 2 (no food, no experimenter to no food, experimenter present). Time 2 refers to the transition between Condition 2 and Condition 3 (no food, experimenter present to food present, experimenter absent). Time 3 refers to the transition between Condition 3 and Condition 4 (food present, experimenter absent to food and experimenter present).

		Latencies (in seconds)		
Subject	Gesture type	Time 1	Time 2	Time 3
Lucy	Hold Hand Out	-2	-22	-46
	Food Beg2	6	-14	-38
Carl	Hold Hand Out	0	-19	-42
	Whole Hand Point	46	27	4
Merv	Hold Hand Out	3	-18	-38
Duncan	Hold Hand Out	-1	-16	-34
Brodie	Food Beg2	6	-14	-35
	Food Beg2	11	-9	-30
Boisfeuillet	Whole Hand Point (at camera)	9	-13	-38
Ellie	Whole Hand Point	41	19	-2
	Whole Hand Point	48	26	5
Clint	Hold Hand Out	50	25	5
Callie	"Barter"	46	29	5
Reba	Whole Hand Point	52	33	8
	Food Beg2	61	42	17
Cheetah	Food Beg2	47	27	8
Ossabaw	Index Finger Point	57	36	15

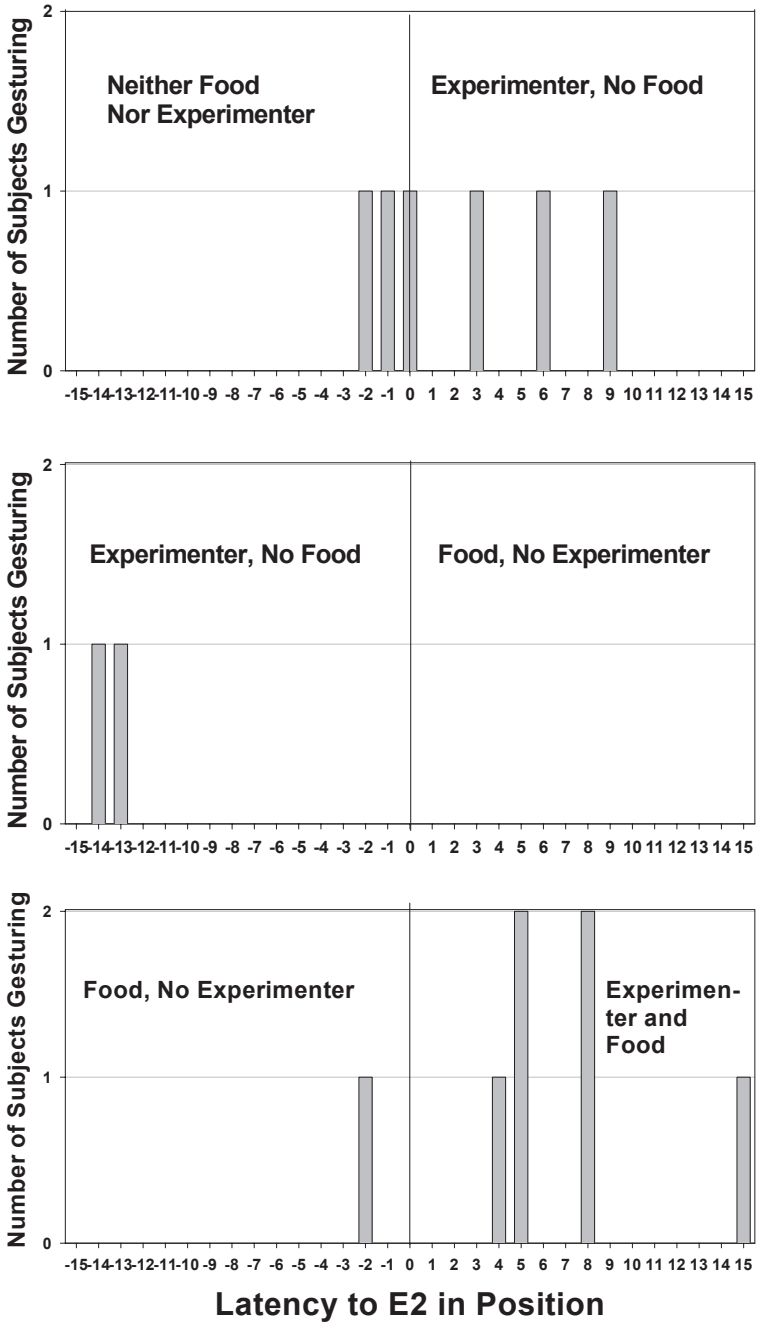

Figure 3. Distribution of gestures with respect to the time E2 was fully in position during each of the three transitions in Experiment 1. Top panel depicts the transition from Condition 1 to Condition 2 (T1), the middle panel depicts the transition from Condition 2 to Condition 3 (T2), and the bottom panel depicts the transition from Condition 3 to Condition 4 (T3). One individual, Carl, is represented twice, at 0 seconds in the top panel and at +4 seconds in the bottom panel.

Table 7. Individuals who gestured in Experiment 1. Zeros denote "no gesture observed," whereas ones denote "gesture observed."

	Condition in which gestures initiated				
	1	2	3	4	Total
Boisfeullet[a]	0	1	0	0	1
Callie[a]	0	0	0	1	1
Reba[a]	0	0	0	1	1
Ossabaw[a]	0	0	0	1	1
Cheetah[a]	0	0	0	1	1
Lucy	1[b]	1[b]	0	0	2
Carl	0	1[b]	0	1[b]	2
Merv	0	1[b]	0	0	1
Duncan	1[b]	0	0	0	1
Brodie	0	1[b]	0	0	1
Ellie	0	0	1[b]	1[b]	2
Clint	0	0	0	1	1
Amanda	0	1[c]	0	0	1
Anna	0	0	0	1[c]	1
Winston	0	0	0	1[c]	1
Puddin'	0	0	0	1[c]	1
Storer	0	0	0	1[c]	1
Totals	2	6	1	11	20

[a]These subjects were visible on camera throughout all four conditions.
[b]These gestures were recorded on camera.
[C]These gestures were observed by E2, but not recorded on camera.

there were five gestures recorded by E2 (during Conditions 2 and 4) that were not observed on camera, whereas any gestures exhibited in the absence of an observer and not recorded on film would not have been available for analysis. This constitutes observational bias against the null hypothesis. Balanced against this is an observational bias such that the chimpanzees were visible on camera, on average, 10 seconds longer when E2 was absent than when E2 was present; this latter constitutes observational bias against the research hypothesis. Given these caveats, the

chimpanzees in this study did not distribute their gestures randomly with respect to the four conditions: Cochran's Q (3, N = 17) = 13.78, $p < .05$. Inspection of Table 7 reveals that the majority of gestures (17 of 20) were initiated in Conditions 2 and 4. Nearly twice as many gestures were initiated in the presence of both food and an experimenter, compared to when an experimenter, but no food was present(11 and 6, respectively). Thus, although the presence of food appears to facilitate gesturing, the presence of food (a banana) alone is not a significant factor in the propensity to exhibit gestural behaviors by chimpanzees.

Additional Results

The effect of the presence of food on the propensity to vocalize was assessed by comparing vocal behaviors across Conditions 2 (experimenter present, no food) and 4 (both food and experimenter present). Previous research has established that chimpanzees' propensity to vocalize is, in part, a function of the amount of food presented (e.g., Hauser & Wrangham, 1987; Hauser, Teixidor, Field, & Flaherty, 1993). The present data presented an opportunity to partially replicate that finding, as the subjects were exposed to a change in conditions from one in which there was no food visible, but an experimenter present (Condition 2) to a condition in which there was both food and an experimenter present (Condition 4). Eight subjects exhibited a change in vocal behavior across the two conditions. Of these eight subjects, 1 vocalized in Condition 2, but not in Condition 4, whereas the remaining 7 subjects did not vocalize in Condition 2 but did vocalize in

Condition 4. Given the previously published reports by Hauser and his colleagues (Hauser & Wrangham, 1987; Hauser et al., 1993), justification exists for application of a one-tailed test. This would halve the probability associated with the observed distribution, and using the binomial test the difference in vocalization as a function of conditions 2 versus 4 was statistically significant(p = .035). Therefore, the findings suggest a facilitatory effect of food on vocal production in chimpanzees.

With respect to gaze alternation between the banana and the experimenter (which could only be assessed in Condition 4), there was a significant association between subjects' propensity to gesture and to exhibit gaze alternation between the experimenter and the food (χ^2 (1, N = 35) = 5.45, p < .05), which is consistent with previous findings in our laboratory (Leavens & Hopkins, 1998). Twelve of the 24 subjects who did not gesture in Condition 4 exhibited gaze alternation between the banana and the experimenter (50%), whereas ten of the eleven subjects who did gesture in Condition 4 exhibited concomitant gaze alternation between the experimenter and the banana (91%). Thus, the present data demonstrate an association between visual monitoring behavior and gestural production in chimpanzees, as reported in previous studies (Krause & Fouts, 1997; Leavens & Hopkins, 1998; Leavens et al., 1996).

CHAPTER 6

EXPERIMENT 2: EFFECTS OF FOOD DISPERSION ON POINTING

The purpose of this experiment was to explore the effects of a manipulation of food dispersion on the number of fingers extended by chimpanzees while pointing. Two conditions were employed: food was either clustered (2 cm. between adjacent food items) or relatively spread out (20 cm. between adjacent food items).

Method

Subjects

Subjects were 83 chimpanzees (40 females) housed at the YRPRC. All subjects were treated in accordance with the ethical standards of the American Psychological Association (American Psychological Association, 1992).

Materials

Two experimenters participated in each trial. Each subject received one each of two trial types (conditions), in randomized order. All randomization procedures throughout this and the following experiment were based on an application of Fellows'(1967) sequences. One seedless grape and 6 peanut kernels were used in each trial. The variable being manipulated was food dispersion. In the present experimental context, the term "dispersion" is used to refer to the distance between adjacent food items. Given a row of seven adjacent food items (see below), when these food items are placed relatively close together, they are

considered here to be less dispersed (or spread) than when seven food items are placed relatively more distantly from each other.

In 20 cm. trials, the grape and six peanut kernels were dispersed in a row approximately 35 cm. from the subjects' cages, parallel with the inside wall of each cage (see Figure 4). The food items were placed on a template constructed from a 1.22 meter length of vinyl baseboard, with small circles placed at appropriate intervals to guide food placement (the entire span of the line of food items was 1.2 meters). The grape was placed in the center position and peanuts placed in the other positions on all trials. The 2 cm. condition duplicated the 20 cm. condition in every respect except the interval between food items, which was 2 cm., forming a line of food items 12 cm. long (see Figure 4). A video camera was placed approximately 1.5 meters from the cage, always to the subject's right and oriented at a 45 degree angle to the cage wall, focused on the front of the cage. The videotaped record was used as a separate record from which reliability estimates were derived. All data used for analysis were recorded directly on data sheets by the second experimenter (see below).

Procedure

Initially, E1 arranged the food items in accordance with trial type, started the videocamera, then departed (after discussion with the doctoral committee, for later trials, the camera was turned on immediately upon the arrival of E1, prior to food placement; however, the rationale for this change in the time at which the

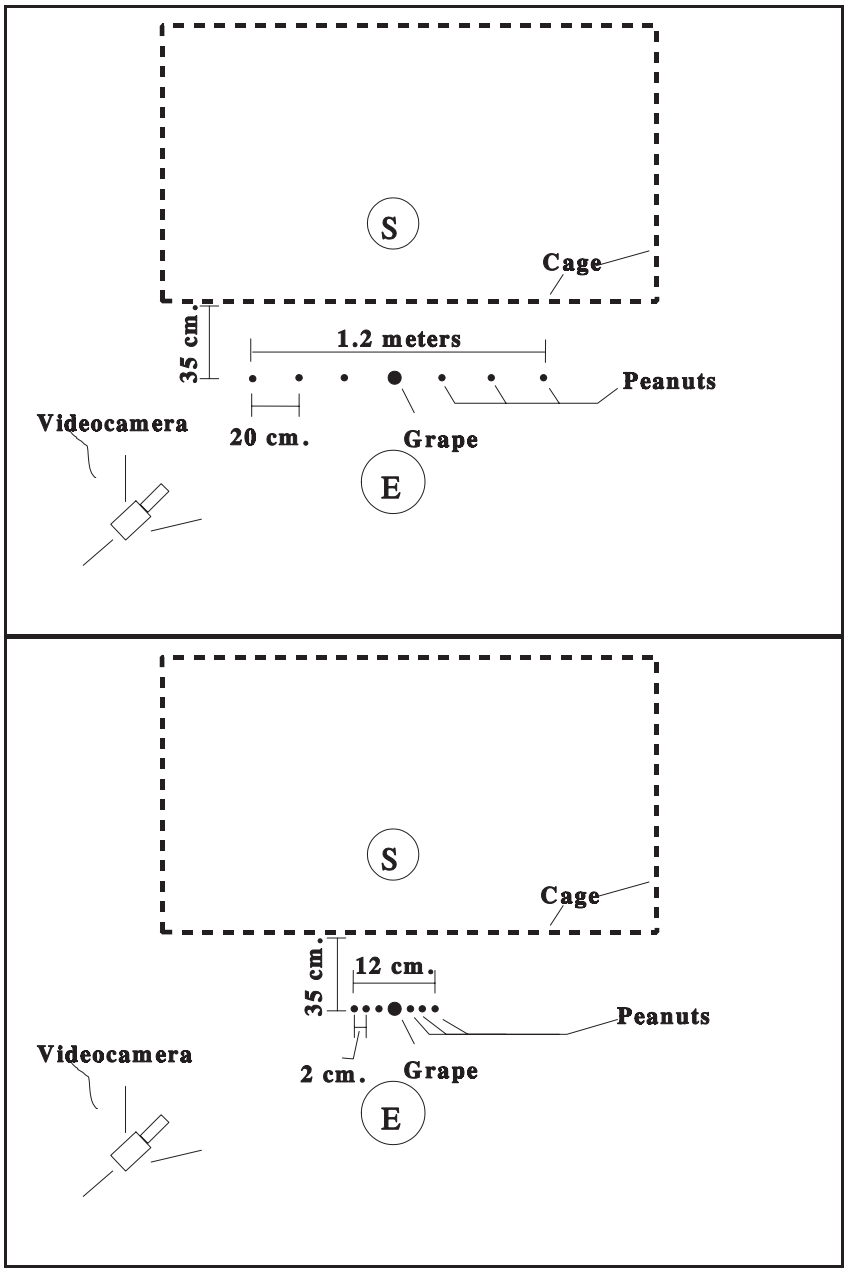

Figure 4. The proposed arrangement for Experiment 2. Depicted in the top panel is the 20 cm. condition, whereas the bottom panel depicts the 2 cm. condition. "S" represents the subject and "E" the experimenter. Drawing not to scale.

videocamera was switched on was obviated when it was decided to administer a separate experiment to assess audience effects, which was described above; see Experiment 1). E2

subsequently arrived and centered himself on the subject's cage, facing the subject. E2 recorded (a) gesture type, if any, (b) the specific fingers extended when the subject pointed (as in standard anatomical nomenclature, the thumb is identified as finger #1, the index finger as finger #2, etc.), and (c) hand used while gesturing (this last measure was in support of the study of hand use while gesturing; these results are not reported here). For example, if a subject pointed to the grape with the index finger of the left hand, this was be recorded as L2; a whole hand point in the same context was recorded as L1-5. E2 responded to any apparent communicative behavior by the chimpanzees (vocalizations or gestures) by delivering the grape and ending the trial. E2 recorded on a data sheet the behavior he construed as communicative. Each subject was observed until he or she exhibited a communicative gesture or until at least 30 seconds had elapsed since the arrival of the experimenter. In other words, all subjects were given at least 30 seconds to respond. Trials were terminated upon response and only those subjects who responded within 30 seconds were included for analysis. Observation continued beyond 30 seconds for many subjects, in order to increase the opportunity for collection of data on hand use, for another study. Upon response, the subjects were reinforced with the grape. At the conclusion of each trial, E2 turned off the videocamera.

Behavioral Measures

Behaviors recorded were as listed in Table 5, except that no attempt was made to differentiate whether gestures

were object- or person-directed, because of the spatial contiguity of food and experimenter in this study (see Figure 4).

Data Analysis

Each subject was categorized as to whether or not they gestured. Among those who gestured, those who pointed were categorized as to whether they exhibited whole-hand or single-digit pointing (for purposes of this analysis, those who extended 2 or more fingers were categorized as exhibiting whole hand points). The null hypothesis was that chimpanzees will not become more precise in pointing (i.e., will not exhibit proportionately more single-digit points) as food dispersion decreases; rejecting the null hypothesis will support the interpretation that their pointing became either more precise or less precise in structure. The McNemar test for symmetry (described in Siegel, 1956, pp. 63-67) was used to analyze results. In this experimental context, this test compares the number of individuals who switch from whole hand points to single-digit points with the number of individuals who switch from single-digit points to whole hand points (the McNemar test is insensitive to responses that do not change across conditions). Alpha was set at .05 and the test was two-tailed.

Reliability

Reliability with respect to gesture type was assessed with an experimenter reviewing and coding 20% of the videotaped trials. Reliability estimates were expressed in terms of Cohen's kappa, a conservative measure that corrects for agreement by chance (Bakeman & Gottman, 1986).

Interobserver reliability on gesture type was calculated to be Cohen's kappa = .81, which is very high.

Results

The overall rate of gestural response was high: 65 chimpanzees gestured during both of the two trials. Five subjects gestured in the 2 cm. but not the 20 cm. condition, and five gestured in the 20 cm. but not the 2 cm. condition. Eight subjects did not gesture in either condition. There was no influence of trial order (i.e., whether the 2 cm. or 20 cm. condition was presented first): 73 subjects either gestured or did not gesture on both trials, and the number of individuals who either (a) gestured in the first trial, but not the second trial or (b) did not gesture in the first trial, but gestured in the second trial, was exactly equal (five in each case). With respect to pointing, specifically, twenty-four chimpanzees pointed on both trials. Of these only four pointed with the index finger; thus, too few subjects pointed with the index finger for statistical analysis. Of these four, two pointed with the index finger in the 2 cm. condition and with the whole hand in the 20 cm. condition and the other two exhibited the opposite pattern. The manipulation of food dispersion in this experiment had no influence on the number of fingers extended while pointing.

CHAPTER 7

EXPERIMENT 3: EFFECTS OF HIDDEN AND VISIBLE FOOD ON GESTURES

This experiment addressed two questions: (a) do chimpanzees alter their communicative behaviors in accordance with whether or not an observer can see the food, and (b) how good are chimpanzees at communicating about hidden food location?

Method

Subjects

Subjects were 101 chimpanzees (53 females) housed at the YRPRC. These chimpanzees had not received language training. All subjects were treated in accordance with the ethical standards of the American Psychological Association (American Psychological Association, 1992).

Materials

Two experimenters participated in each trial. Each subject received one each of two trial types (conditions), in randomized order. Two identical plastic buckets were inverted and placed approximately 70 cm. from the subjects' cages, approximately 1.5 meters apart (Figure 5). Bananas were used to elicit communicative behaviors. All trials were videotaped with a videocamera, as depicted in Figure 5, to enable the computation of reliability estimates.

Procedure

Experimenter 1 placed a banana either on top of an inverted bucket (VISIBLE condition) or beneath an inverted

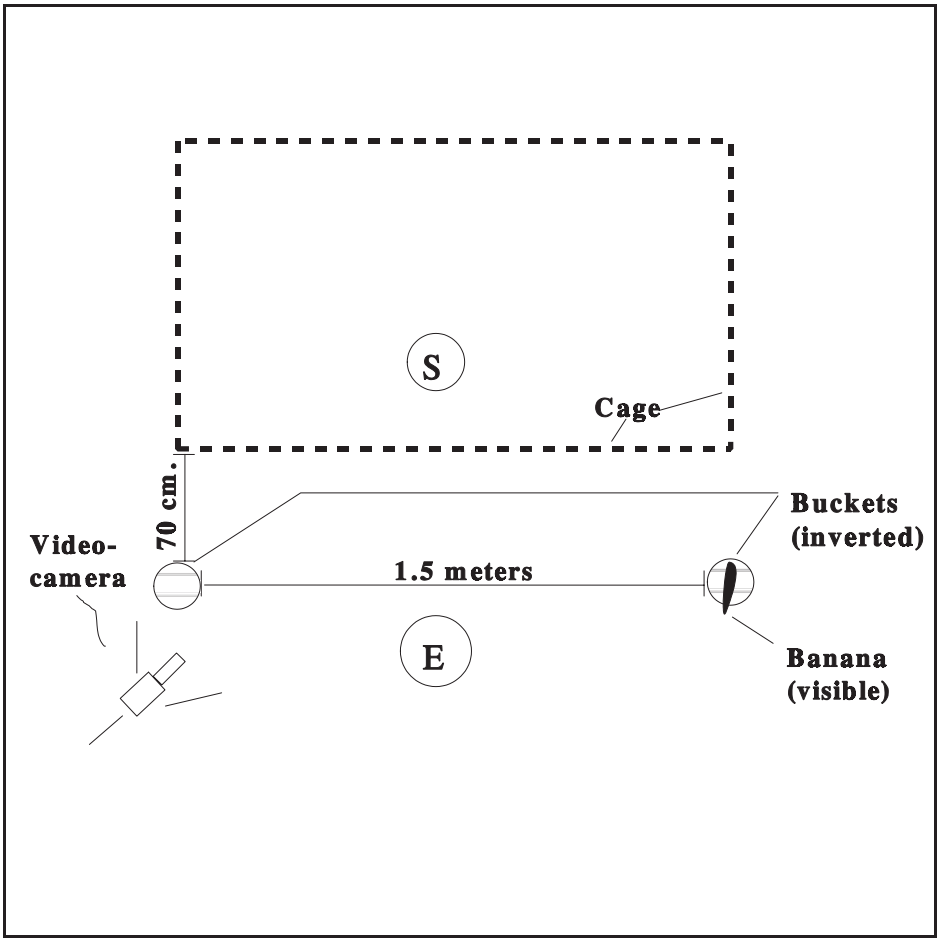

Figure 5. Setup for the experiment on the effects of hidden food on gestural production. The VISIBLE condition is depicted, in which a banana was placed on the inverted bottom of a plastic bucket. In the HIDDEN condition, a banana was placed beneath an inverted bucket. "S" represents the subject and "E" the experimenter. Drawing not to scale.

bucket (HIDDEN condition), according to a randomized schedule (Fellows, 1967). E1 then started the videocamera and departed. E1 did not communicate the location of the banana to E2. Subsequently (at least 30 seconds later), E2 arrived, centered himself between the buckets and attempted

to engage the visual attention of the subject by looking at the subject and calling out the subject's name.

As in Experiment 2, described above, in the VISIBLE condition, E2 responded to any apparent communicative behavior, as defined in Table 5, by delivering the banana to the subject and every subject was given at least 30 seconds to respond. Although observation continued for more than 30 seconds for some subjects (again, in support of a study of hand use), only subjects who either (a) responded on camera within 30 seconds of the arrival of E2 or (b) did not respond, are included in the following analyses. Bananas were delivered upon response or at the termination of the trial. In the HIDDEN condition, after establishing a state of mutual attention with the subject, defined as both subject and experimenter looking at each other, E2 attempted to determine which bucket concealed the banana through interpreting the gestures and postures of the subject. If the bucket that E2 checked did conceal the banana, it was delivered immediately to the subject. If the bucket did not conceal the banana, then E2 immediately overturned the remaining bucket and delivered the banana to the subject. If no obvious communicative gesture was exhibited, then after a minimum interval of 30 seconds after the arrival of E2, he overturned one or both buckets, delivering the banana, when found, to the subject. After delivery of the banana, E2 turned off the videocamera and departed.

E2 recorded (a) whether or not the subject gestured, (b) gesture type, (c) whether or not the subject vocalized, and (d) whether or not the subject looked successively

between the observer and one or both of the buckets. The videotape was coded with respect to the number and type of gestures. The videotapes were scored by an experimenter for reliability estimates.

Data Analysis

Analyses assessed the influence of observer visual access on the gestural communication of the chimpanzees. First, subjects were categorized with respect to whether they gestured in one condition but not in another. Second, subjects were categorized with respect to whether the orientation of their gestures changed across conditions; i.e., whether they altered the orientation of their gestures from being directed toward E2 to being directed toward a bucket or vice versa. McNemar's tests for symmetry was employed for these analyses and tests were two-tailed.

An additional analysis focused on the effectiveness with which chimpanzees communicated about object location to E2. As described in the Method section of Experiment 1, analyses were also conducted to ascertain whether having the opportunity to observe others in the tasks had any bearing on (a) subjects' efficacy in communicating about hidden bananas and (b) subjects' propensity to gesture.

Reliability

In total, there were 202 trials of observation, two trials for each subject. Reliability estimates were derived from comparisons between the original data sheets and a later viewing of the videotapes. Because not every subject stayed within camera view throughout the observation periods, only a subset of trials were available for

reliability estimates. Only trials in which the subject was visible on the videotaped record from the time E2 arrived to the time the subject was reinforced were used. There were 91 trials over both the visible and hidden conditions that met this criterion; hence, reliability for gesture type was assessed on 45% of the trials. Cohen's kappa for gesture type was .73, demonstrating high reliability between the videotaped record and the record created by E2. Reliability estimates for whether or not gaze alternation or vocalization occurred were assessed on 42 and 48 trials, respectively, constituting 21% and 24%, respectively, of the trials. Cohen's kappa for whether or not gaze alternation was exhibited between the baited bucked and E2 = .82. Cohen's kappa for whether or not subjects vocalized = .75.

Results

Influence of Hiding the Banana

To statistically compare the effects of hiding food, subjects were selected who met each of two conditions: (a) that they either gestured within 30 seconds of the arrival of E2 or did not respond and (b) that they were also observed during both the visible and hidden conditions. Sixty-eight chimpanzees met both criteria. There was no influence of test order (i.e., behaviors exhibited on Trial 1 compared to behaviors exhibited on Trial 2) on the propensity to gesture; that is, 39 subjects gestured on both trials, 15 subjects gestured on neither trial, seven subjects gestured on Trial 1, but not on Trial 2, and seven subjects did not gesture on Trial 1, but gestured on Trial 2 (calculation of a McNemar test in this circumstance is not

possible, because the numerator, which would be seven minus seven, is zero). Fifty-four of these subjects either gestured in both conditions (visible and hidden banana) or did not gesture in either condition; 14 gestured in one condition only. There was no influence of hiding the food on subjects' propensity to gesture (McNemar test, $\chi^2(1, N = 14) = .07$, $p > .05$).

To check for the possibility that subjects who had opportunities to see cagemates in the task might gesture more frequently, the experiments were categorized as follows: (a) the first Experiment 3 to be administered in a specific cage (FIRST), (b) the second Experiment 3 to be administered in a specific cage (SECOND), and (c) the third through eighth Experiment 3s to be administered in a specific cage (THIRD). The number of chimpanzees in each of these three categories, FIRST, SECOND, and THIRD was 38, 31, and 32, respectively. Each experiment comprised two observations on each of these 101 chimpanzees; thus, there were 202 observations. The numbers of observations attributed to FIRST, SECOND, and THIRD, therefore, were 76, 62, and 64, respectively. The percent of experiments in each of FIRST, SECOND, and THIRD in which chimpanzees gestured at least once (in either the visible or hidden condition or both) was 84%, 74%, and 66%, respectively. Thus, there was no apparent facilitatory effect of observing the experiments on gestural production.

To statistically compare the direction of gestures across conditions, the 68 subjects used in the above analysis were re-categorized as having (a) failed to gesture

in one or both conditions (n = 28), (b) gestured toward E2 in both conditions or gestured toward a bucket in both conditions (n = 28; i.e., these subjects exhibited no change in the direction of their gestures across conditions), (c) gestured toward E2 in the visible condition and toward a bucket in the hidden condition (n = 7; i.e., these subjects increased the specificity of their gestures when the food was out of view), and (d) gestured toward a bucket in the visible condition and toward E2 in the hidden condition (n = 5; i.e., these subjects increased the specificity of their gestures when the food was in plain view). There was no influence of hiding the food on the specificity of subjects' gestures (McNemar test, $\chi^2(1, N = 12) = .08$, $p > .05$).

There was no influence of test order on the propensity to vocalize; that is, 15 subjects vocalized on both trials, 39 subjects vocalized on neither trial, four subjects vocalized on Trial 1, but not on Trial 2, and 10 subjects did not vocalize on Trial 1, but vocalized on Trial 2 (McNemar's test $\chi^2(1, N = 14) = 2.57$, $p > .05$). Fifty-four of the subjects either vocalized in both conditions (visible and hidden banana) or did not vocalize in either condition; fourteen vocalized in one condition only. There was no influence of hiding the food on subjects' propensity to vocalize (McNemar test, $\chi^2(1, N = 14) = 0.29$, $p > .05$).

With respect to gaze alternation between a bucket and the experimenter, there was no influence of test order on the propensity to exhibit gaze alternation; that is, 43 subjects exhibited gaze alternation on both trials, three subjects exhibited gaze alternation on neither trial, 11

subjects exhibited gaze alternation on Trial 1, but not on Trial 2, and 11 subjects did not exhibit gaze alternation on Trial 1, but did so on Trial 2 (calculation of a McNemar test in this circumstance is not possible, because the numerator, which would be 11 minus 11, is zero). There was no influence of hiding the banana on the propensity to exhibit gaze alternation between a bucket and the experimenter (McNemar's test, $\chi^2(1, N = 22) = 0.18$, *ns*).

Subjects' propensity to exhibit gaze alternation was not associated with their propensity to exhibit vocalizations in either the visible or hidden conditions (Visible Condition: $\chi^2(1, N = 68) = 3.27$, *ns*; Hidden Condition: $\chi^2(1, N = 68) = 0.10$, *ns*).

Subjects' propensity to gesture was also not associated with their propensity to exhibit vocalizations in either the visible or hidden conditions (Visible Condition: $\chi^2(1, N = 68) = 0.40$, *ns*; Hidden Condition: $\chi^2(1, N = 68) = 2.00$, *ns*).

However, subjects' propensity to exhibit gestures was associated with their propensity to exhibit gaze alternation in both the visible and hidden conditions (Visible Condition: $\chi^2(1, N = 68) = 5.89$, $p < .05$; Hidden Condition: $\chi^2(1, N = 68) = 5.41$, $p < .05$). In the visible condition, 74% of subjects who gestured also exhibited gaze alternation between a bucket and E2, and in the hidden condition, 76% of subjects who gestured exhibited this gaze alternation. Among subjects who did not gesture, 40% of subjects exhibited gaze alternation in the visible condition and 38% of subjects exhibited gaze alternation in the hidden condition.

Effectiveness of Chimpanzee Communication in the Hidden Condition

This analysis uses data from the hidden condition only and includes all available subjects. The experimenters failed to record whether or not the baited bucket was selected first by E2 in four cases; hence, only 97 trials are available for this analysis. The baited bucket was selected by E2 on 69 of the 97 trials (71% correct), which is statistically better than chance (50%), binomial test: $Z = 3.65$, $p < .001$). Thus, using only first trial data, the chimpanzees communicated effectively about the location of the baited bucket.

To assess whether E1 may have unconsciously cued E2 as to the location of the banana, subjects were categorized with respect to whether they (a) alternated their gaze between the baited bucket and E2, (b) alternated their gaze between the unbaited bucket and E2, or (c) did not exhibit gaze alternation (Figure 6). The distribution differed significantly from chance (χ^2 (2, $N = 97$) = 40.52, $p < .001$). Examination of Figure 6 reveals that performance in the absence of gaze alternation is very close to 50%, which suggests that E1 did not cue E2 as to the location of the banana.

This failure to find evidence for inter-experimenter cueing of food location is echoed by analysis of the directions of gestures. Of the 97 chimpanzees, 88 either gestured or did not gesture in the hidden condition (the remainder were such gestures as rump presents and apparent attempts to barter). Subjects were categorized with respect

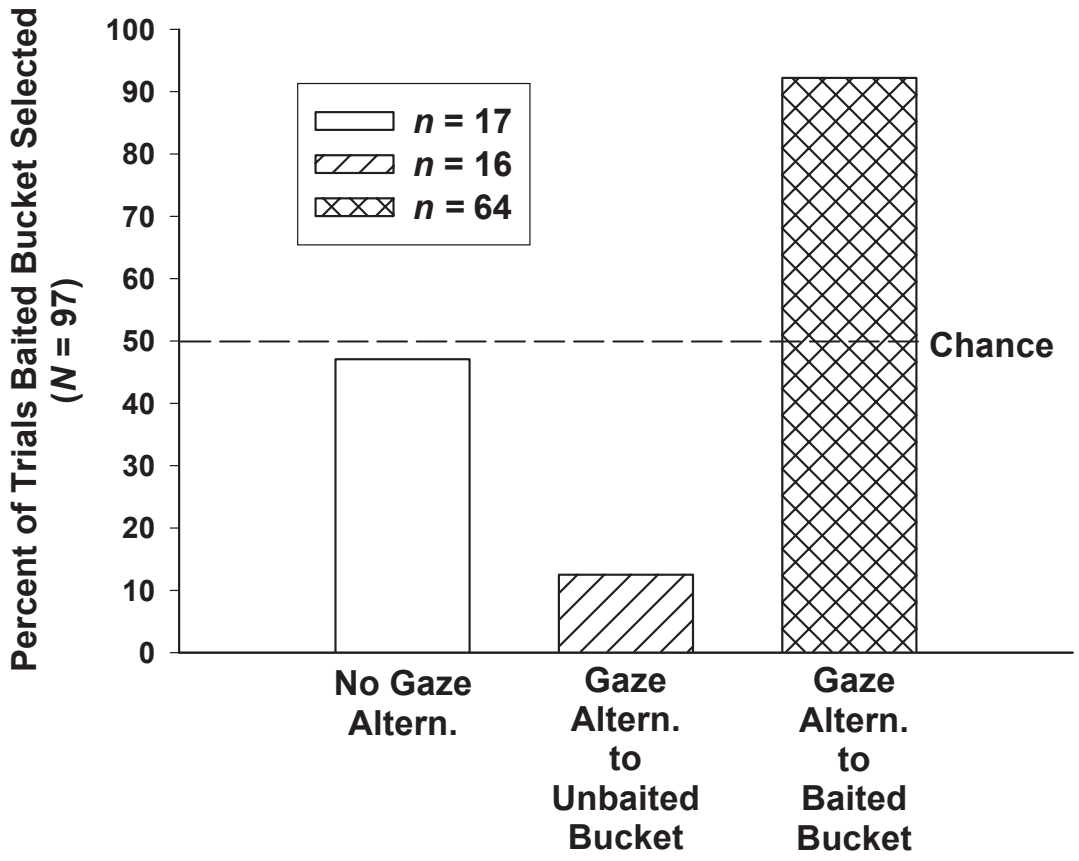

Figure 6. Percent correct as a function of whether subjects were deemed to (a) exhibit no gaze alternation, (b) gaze alternation between the observer and the unbaited bucket, and (c) gaze alternation between the observer and the baited bucket.

to whether they (a) did not gesture, (b) gestured toward the unbaited bucket, (c) gestured toward E2, or (d) gestured toward the baited bucket. The distribution differed significantly from chance ((χ^2 (3, N = 88) = 9.51, p < .05). E2 chose the correct bucket during 100% of the 23 trials in which subjects gestured toward the baited bucket. When subjects did not gesture, E2 chose the correct bucket during 60% of the 25 such trials. When the subjects gestured toward the unbaited bucket, E2 chose the correct bucket on

four of six such trials (67%). Finally, when subjects gestured toward the experimenter, E2 chose the correct bucket on 22 of 34 such trials (65%). Again, performance in the absence of gestures did not differ substantially from 50%, also suggesting that E1 did not cue E2 as to the location of the banana. The relatively high performance in the presence of those subjects who directed their gestures towards the unbaited (67%) bucket may be accounted for by the incongruity between their gaze orienting and gestural behaviors: five of these six subjects exhibited gaze orienting behavior successively between the baited bucket and E2 (the remaining subject exhibited no gaze alternation).

It was not the case that the first subjects in each cage exhibited any decrement in performance, relative to later subjects in a cage. Subjects were categorized as being (a) the first subject in a cage to experience the task (n = 37), (b) the second subject in a cage to experience the task (n = 30), or (c) the third through eighth subjects in a cage to experience the task (n = 30); performance was 73%, 73%, and 63%, respectively. Thus, there was no apparent facilitatory effect of observing the experiment on the effectiveness of communication about hidden objects.

Additional Analyses

The influence of observer presence on the propensity to gesture was assessed. Only subjects who gestured on camera within 30 seconds of the arrival of E2 were included. In the visible condition, 50 subjects met this criterion and there was a significant effect of observer presence on the

emission of gestures (Binomial test, $Z = 4.81$, $p < .0001$; see Figure 7). In the hidden condition, 51 subjects met the criterion and there was also a significant effect of observer presence on the emission of gestures (Binomial test, $Z = 5.60$, $p < .0001$; see Figure 8). This analysis demonstrates that the findings in Experiment 1, in which four conditions were presented in constant order to 35 chimpanzees, cannot be explained by an endogenous periodicity in the emission of gestures triggered by the presentation of food (compare Figure 3 with Figures 7 and 8). Thus, with respect to the time of the arrival of an observer, chimpanzee gestures are neither obviously periodic nor random.

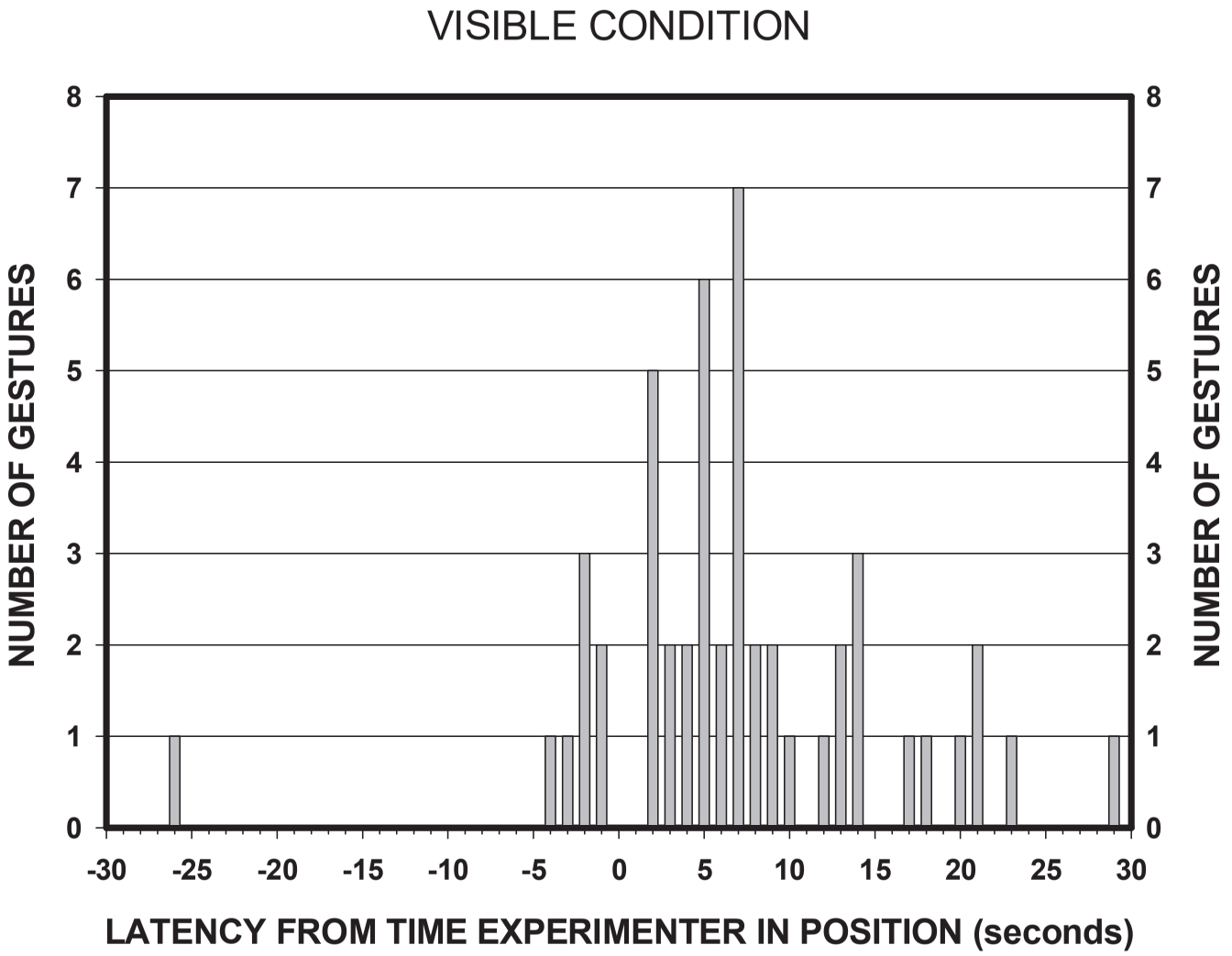

Figure 7. Latency to first gesture relative to the time the experimenter arrived in position when a banana was visible (*N* = 50 gestures).

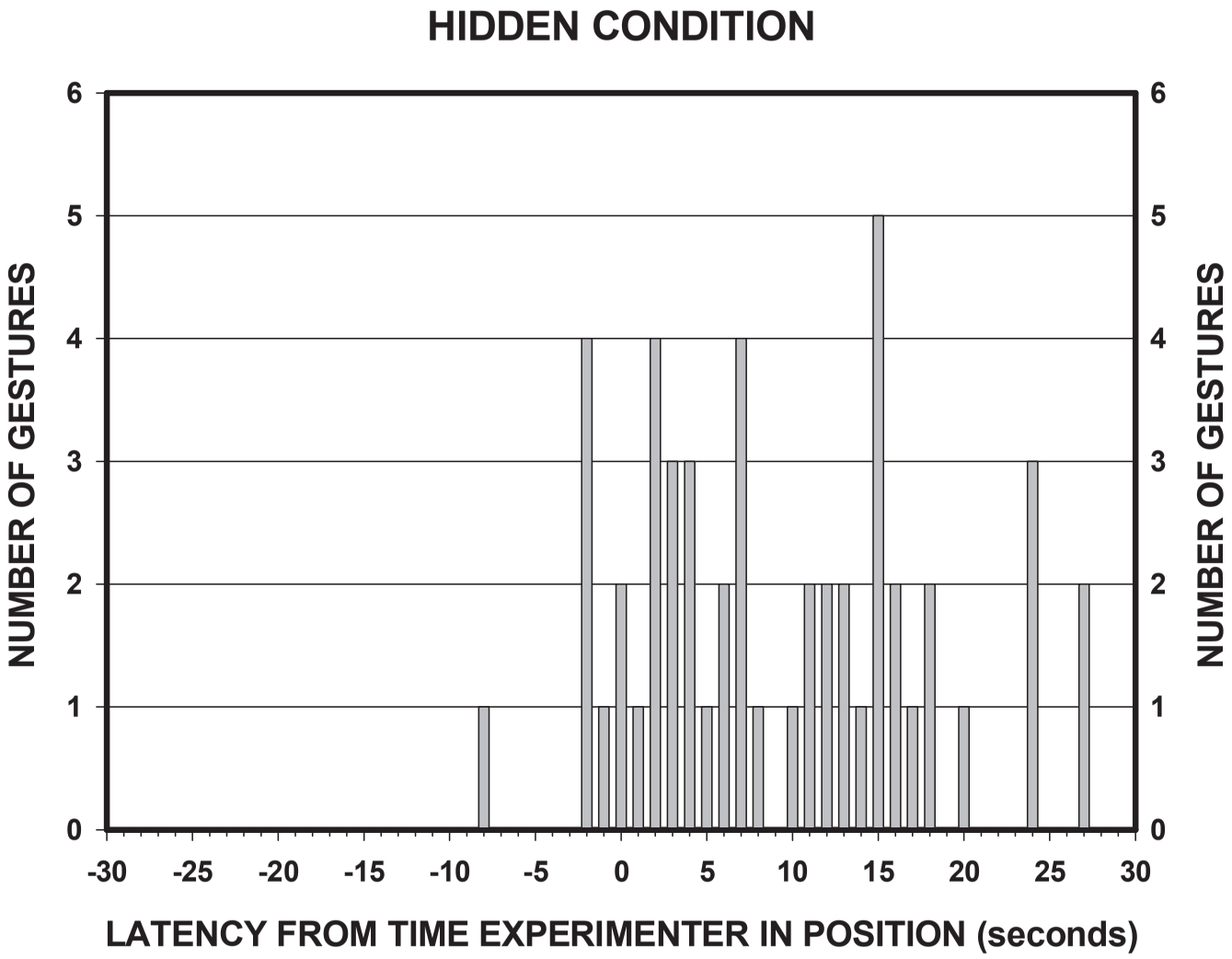

Figure 8. Latency to first gesture relative to the time the experimenter arrived in position when a banana was hidden (*N* = 51 gestures).

CHAPTER 8

GENERAL DISCUSSION

Two conclusions are warranted from the data reported here: (a) gesturing by chimpanzees is strongly influenced by the presence or impending arrival of an audience or observer (Experiments 1 and 3) and (b) chimpanzees communicate effectively about the location of a hidden banana, even on "first-trial" exposure to the task (Experiment 3). The results from Experiment 2, which manipulated the dispersion of an array of food items indicated that the manipulation of the amount of spread between food items from 2 cm. to 20 cm. had no apparent influence on the number of fingers protruded while pointing in this sample of chimpanzees.

The significance of the audience effect reported here lies in the sample sizes involved in Experiments 1 and 3. Previous reports of the effect of observer presence on gestures involved relatively small samples, ranging from one to three subjects (e.g., Call & Tomasello, 1994; Leavens et al., 1996). In Experiment 1, 17 chimpanzees gestured and these gestures were significantly related to the presence of an observer. In Experiment 3, 50 chimpanzees gestured within 30 seconds of the arrival of an observer in the condition in which a banana was visible to both chimpanzee and observer. Also in Experiment 3, 51 chimpanzees gestured within 30 seconds of the arrival of an observer in the condition in which a banana was hidden beneath a bucket, so

that only the chimpanzee knew the location of the banana. In both the visible and hidden conditions, chimpanzee gestures were significantly related to the presence or impending arrival of the observer. Thus, the audience effect on gestures previously reported with relatively small samples, has been convincingly replicated here three times with large samples, using only "first-trial" data.

It has been previously argued that, with respect to whole-hand pointing, the necessity of an audience reflects that these whole-hand points are communicative in function, not attempts to grasp obviously out-of-reach food (Leavens & Hopkins, 1998; Leavens et al., 1996). The present data, on the largest samples extant, strongly support this conclusion. Chimpanzee gestures require an audience; their limb and finger extensions are not simply attempts to reach through the cage mesh to directly grasp obviously unreachable food. This does not, of course, demonstrate that, for example, chimpanzees who do extend limbs and multiple fingers toward distant food in the presence of an observer are self-consciously using the limb and hands to "refer." In behavior-analytic terms, the observer might be termed an "occasion-setting" stimulus for the emission of gestures (e.g., Mazur, 1994; Rescorla, 1987).

Other than an abstract by Franco and Butterworth (1990), there are no published studies of the effects of observer presence on the propensity to gesture in human infants. Franco and Butterworth reported a facilitatory effect of the presence of a caregiver on the propensity to gesture by human infants as young as 18 months, compared to

a condition in which caregivers were absent. A criticism of that report is that infants who experience the absence of their caregivers may simply exhibit a generalized behavioral inhibition due to distress (Franco, personal communication). Thus, comparisons between apes and human infants in their sensitivity to observer presence are obviated by the lack of data on human infants. In an ongoing, cross-sectional study at the University of Sussex (Leavens & Todd, in prep.), the influence of the presence and degree of visual attention exhibited by primary caregivers is being manipulated in groups of 6-, 9-, 12-, 15-, and 18-month-olds to assess developmental changes in the sensitivity of gestures to the aspects of caregiver presence and attention, so comparisons with results from apes will be possible in the near future. Preliminary data from that study suggest that parental attention or the absence thereof has no differential effect on the propensity of young infants (6 to 9 months of age)to visually regard an animated mannequin, but that after 12 months of age, infants' visual regard of an animated mannequin is facilitated by parental attention, compared to a condition in which parents are present, but reading a magazine (i.e., ignoring the infant and the mannequin; Leavens & Todd, in prep.).

In contrast to the paucity of studies of human infants in which the effects of observer presence are assessed, there are many studies of the developmental transition from pointing without gaze orientation to social partners to pointing with visual monitoring of social partners (e.g., Franco & Butterworth, 1996; Moore & Dunham, 1995). As noted

in the introduction (see Figure 1), pointing with concomitant gaze alternation between the target of a point and a social partner emerges about 3 months later than pointing without such visual regard. A central methodological limitation of this area of research is that once pointing begins, visual monitoring of the social partner is traditionally defined in terms of the latency of this looking relative to the time of occurrence of the gesture (specifically, pointing with the index finger). When infants look to the social partner within, typically, two seconds of gesturing, they are categorized as having exhibited visual checking, otherwise, they are categorized as not having exhibited visual monitoring of the social partner (e.g., Franco & Butterworth, 1996). Thus, the developing integration of gestural and visual orienting behavioral systems is currently not well understood. To elucidate this development, ongoing research at the University of Sussex is assessing visual orienting behavior with respect to an external stimulus (animation of a mannequin); this research will permit the assessment of visual orienting behavior throughout the duration of each experimental trial, so that age-related changes in the temporal relations between gestures and visual orienting behaviors can be characterized with reference to an external stimulus (Leavens & Todd, in prep.).

For the purposes of the present study, chimpanzees in the Hidden Condition of Experiment 3 were categorized as having exhibited (a) gaze alternation between E2 and the baited bucket, (b) gaze alternation between E2 and the

unbaited bucket, or (c) no gaze alternation, irrespective of whether they gestured (Figure 6). The judgment of E2 as to the visual orienting behavior of each subject was clearly a strong factor in E2's choice of bucket to overturn. When subjects did not exhibit this successive visual orienting behavior, E2's ability to choose the baited bucket was at essentially chance levels, and when the subjects exhibited gaze alternation between E2 and the unbaited bucket, E2 selected the baited bucket on only 13% of trials, which is substantially less than chance. Thus, chimpanzees communicate effectively about the location of hidden food even without consideration of their gestural behaviors. The data are insufficient to suggest that this gaze behavior is anything other than a perseverative response, but the finding substantiates, with a very large sample, Menzel's (1973) observation that chimpanzees do not often point manually because they don't have to; that is, because sufficient information is provided by their visual orienting and postural cues to locate hidden food.

Nevertheless, gestural behavior was a frequent accompaniment to successive visual orienting between an observer and hidden food. Fifty-one chimpanzees in the Hidden Condition of Experiment 3 gestured within 30 seconds of the arrival of E2. Yet the suite of gestures exhibited did not differ between the conditions in which (a) a banana was visible to both chimpanzee and experimenter and (b) the banana was hidden from the experimenter and invisible to the chimpanzee (who had seen the banana being hidden). Hiding the banana had no apparent influence on the propensity to

gesture, on gesture type, on the propensity to vocalize, or on the propensity to exhibit gaze alternation between an observer and the location of a banana.

This finding is in contrast to that reported by O'Neill (1996) with two-and-a-half-year-old children; the children exhibited more frequent gestures (mostly pointing) when their parents had not seen a container being baited than when the parent had seen this baiting. The present study did not have a condition in which E2 had seen a banana being hidden, so comparisons with O'Neill's study are tenuous, but two interpretations of the data seem obvious. First, it may be the case simply that chimpanzees do not discriminate ignorance in social partners and therefore do not take into account the effects of ignorance on the choice of buckets by E2. On the other hand, the task did not require any additional behavioral response on the part of the chimpanzees to receive their reward, because all subjects were given the banana, irrespective of their communicative behaviors. Differential reinforcement was employed in Experiment 3, but it was differential only with respect to how quickly a given subject received the banana: those who gestured received the banana immediately, whereas those who did not gesture did not receive the banana until at least 30 seconds had elapsed. Given the high level of performance in choosing the baited bucket (71%), the data suggest that the hidden banana condition did not sufficiently challenge the chimpanzees to alter their behavioral repertoires. The high performance level is particularly noteworthy because all subjects were given only one opportunity to respond, which

is in contrast to the experimental procedure employed by C. Menzel (1999), in which a single subject was given hundreds of opportunities to respond.

The procedural features employed in the present studies, which contrast with other research programs in this area, are (a) an emphasis on first-trial data, (b) use of large samples, and (c) relatively naturalistic (in the context of these subjects' captive rearing histories) experimental paradigms. The advantage to using first-trial data is that assessment of behavior is relatively free of interference effects within the context of the studies. The primary disadvantage is that control of the behavior is not demonstrated. While the experiments reported here do not significantly advance our understanding of the *acquisition* of gestural behaviors in chimpanzees, they demonstrate that captive chimpanzees exhibit a pronounced audience effect in their use of gesture. The large samples employed and the relatively naturalistic design of the experiments provided improved external validity compared, for example, to studies that might bring a behavior or class of behaviors under greater experimental control. In other words, these studies demonstrate that captive chimpanzees exhibit both a sensitivity to the presence of an observer in the emission of gestures and the ability to skillfully direct human observers to the location of hidden food, without any explicit training whatsoever, and with by far the largest samples extant. Therein lies the unique contribution of these studies.

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APPENDIX

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YERKES REGIONAL PRIMATE RESEARCH CENTER

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YERKES REGIONAL PRIMATE RESEARCH CENTER (YRPRC)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Agatha		X				X	X	3
Alice		X	X	X				3
Alicia		X						1
Amanda		X			X			2
Angela		X						1
Anna	X	X	X		X	X	X	6
Artemus			X		X	X	X	4
Arthur		X	X		X			3
Artifact		X						1
Artifee		X		X		X	X	4
Augusta		X	X			X	X	4
Barbara		X						1
Barney		X	X			X	X	4
Beleka		X	X	X	X	X	X	6
Bertha		X						1

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Bo		X						1
Boisfeuillet		X	X		X	X	X	5
Boka		X					X	2
Brandy		X	X			X	X	4
Brent		X						1
Brian		X		X				2
Brodie		X	X		X	X	X	5
Brooks							X	1
Callie			X		X	X	X	4
Carl		X	X		X	X	X	5
Carmichael		X				X	X	3
Cheetah		X	X	X	X	X	X	6
Christa							X	1
Clint	X	X	X		X	X	X	6
Colombus		X	X		X		X	4

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Conan		X	X		X	X	X	5
Dara		X	X	X		X	X	5
David		X	X			X	X	4
Debbie		X					X	2
Decamethonium		X						1
Dobbs		X					X	2
Donald		X						1
Drew						X	X	2
Duff		X	X			X		3
Duncan			X		X	X	X	4
Edwina		X			X		X	3
Ellie		X	X		X	X	X	5
Elvira		X				X	X	3
Elwood		X	X	X		X	X	5
Evelyn		X	X			X		3

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Faye						X	X	2
Fiona						X		1
Flora	X							1
Foxy		X	X			X	X	4
Frannie						X	X	2
Fritz		X	X			X	X	4
Garbo		X						1
Gay		X					X	2
Gelb		X	X			X	X	4
Heppie		X		X		X	X	4
Hoboh		X	X		X	X	X	5
Iyk		X				X	X	3
Jacqueline		X				X	X	3
Janice		X					X	2
Jarred		X	X			X	X	4

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Jeannie		X	X			X	X	4
Jenda		X			X		X	3
Jenifere		X	X		X	X	X	5
Jenny		X						1
Jewelle		X				X	X	3
Jimmy Carter		X	X		X	X	X	5
Jolsen			X			X	X	3
Jorge		X			X	X	X	4
Joseph		X		X		X	X	4
Josh		X					X	2
Juan		X					X	2
Julie						X	X	2
Justin		X			X	X	X	4
Kasey		X						1
Katrina		X	X			X	X	4

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Keith		X						1
Kengee		X		X		X	X	4
Kipper		X	X				X	3
Lamar		X	X			X	X	4
Lee		X	X		X	X	X	5
Lena		X				X	X	3
Les		X	X			X	X	4
Leslie		X		X		X	X	4
L'il One		X					X	2
Lizzie		X					X	2
Lolita		X	X				X	3
Lucas						X	X	2
Lucy		X	X	X	X	X	X	6
Lulu		X			X		X	3
Luther		X	X			X		3

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Lux		X					X	2
Marilyn		X					X	2
Marrietta		X				X	X	3
Martha		X						1
Mary		X						1
Mason		X	X	X	X	X	X	6
Maverick						X	X	2
Maxine		X	X			X	X	4
Mega		X	X	X		X	X	5
Melinda		X	X			X	X	4
Melissa		X		X		X	X	4
Merlin						X	X	2
Merv		X	X	X	X	X	X	6
Mortimer		X	X			X	X	4
Ossabaw		X	X		X		X	4

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Patrick						X	X	2
Phillip		X	X		X		X	4
Puddin		X	X		X	X	X	5
Reba		X	X		X	X		4
Rebecca		X						1
Rogger		X	X			X	X	4
Ronald		X					X	2
Rowena		X	X			X	X	4
Rufus		X		X	X	X	X	5
Sabrina		X				X		2
Scott		X	X			X	X	4
Sellers		X	X			X	X	4
Sheena		X				X	X	3
Sheila		X						1
Shirley		X	X			X	X	4

(*table continues*)

SUBJECTS IN STUDIES OF GESTURAL COMMUNICATION AT YRPRC (Continued)

	Leavens, Hopkins, & Bard 1996 (*N* = 3)	Leavens & Hopkins, 1998 (*N* = 115)	Leavens & Hopkins, Unpubl.-a (*N* = 60)	Leavens & Hopkins, Unpubl.-b (*N* = 20)	Present Study Exper. 1 (*N* = 35)	Present Study Exper. 2 (*N* = 83)	Present Study Exper. 3 (*N* = 101)	Total
Sonia		X						1
Storer		X		X	X			3
Suwanee		X	X			X	X	4
Suzanna		X	X	X		X	X	5
Sylvia						X	X	2
Tank		X					X	2
Travis		X						1
Wenka		X			X	X	X	4
Wilma		X	X			X	X	4
Winston		X	X	X	X	X	X	6
Woodruff		X	X			X	X	4
Zana		X					X	2

Notes: Leavens and Hopkins (Unpublished-a), was a study that assessed the influence of the observer possessing a banana on gesture type. This study had two conditions: (a) the experimenter crouched behind an inverted bucket while holding a banana in his hands and (b) the experimenter crouched behind an inverted bucked on which was placed the banana. Leavens and Hopkins (Unpublished -b) was a study that assessed the influence of the size and distance of food on communicative behaviors. This study involved the administration of four trials in random order:

(*table continues*)

(a) small piece of banana, close to cage (.5 meters), (b) small piece of banana, far from cage (1.5 meters), (c) whole banana, close to cage, and (d) whole banana, far from cage. In total, 132 individual chimpanzees have taken part in one or more studies of gestural communication since 1994 (the year data were collected for Leavens et al., 1996). The mean number of studies in which chimpanzees have participated is 3.2 (SD = 1.48; minimum number = 1, maximum number = 6). The mean number of studies in which chimpanzees had participated prior to the experiments reported in the present dissertation is 1.50 (SD = 0.80, minimum number = 0, maximum number = 3).